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Soil survey of the County of Warner, Alberta

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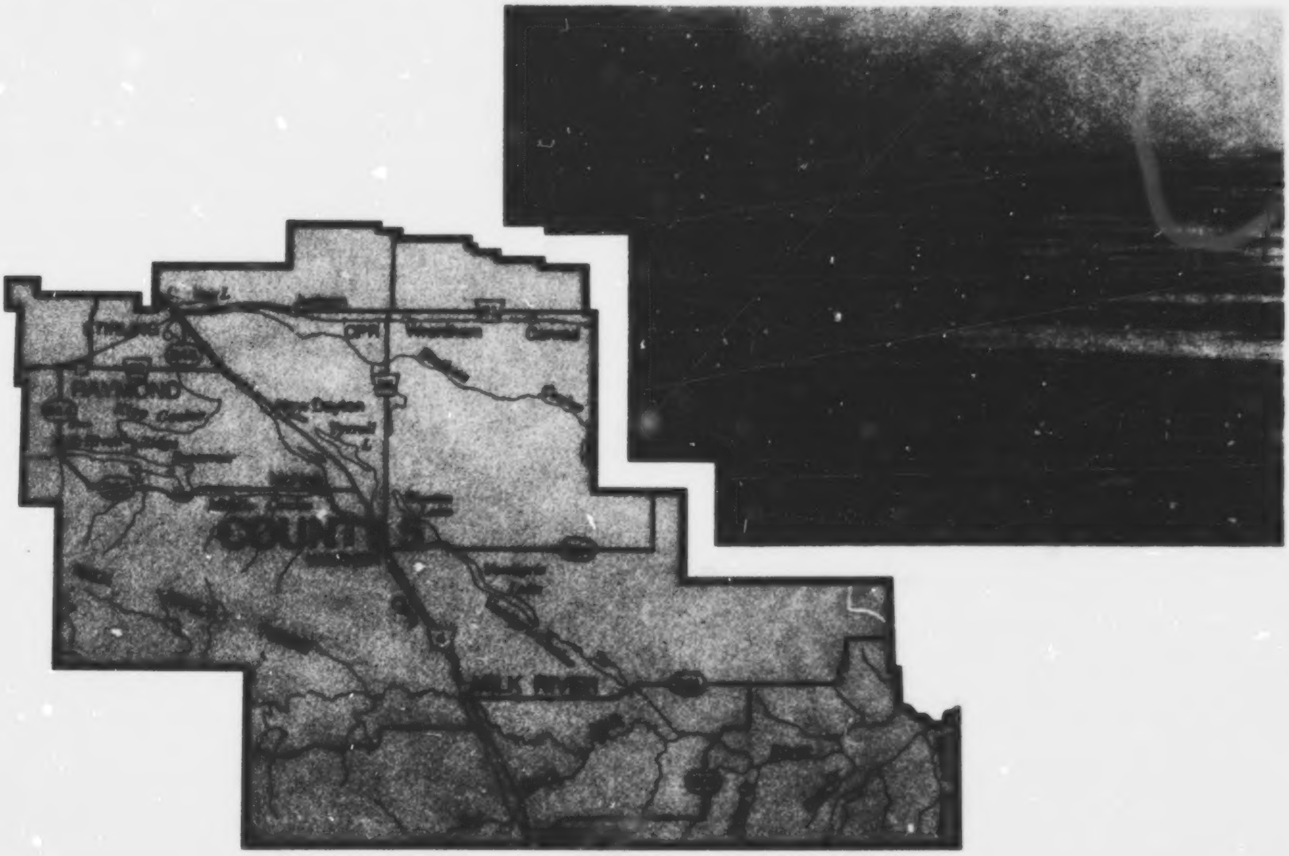

Canada

Soil Survey of the County of Warner Alberta

by

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PREFACE

Soil surveys have been an ongoing endeavour in Alberta since the early 1920's. Although a variety of scales have been used, they all have a common purpose - to gather and provide soil information which is basic to all activities related to this resource.

The early surveys, particularly those prior to 1940, are now out of print. As well, the information they contained was quite general. While useful for broad orientation, the data was generally not detailed enough to meet current planning and management requirements. The Alberta Soil Survey has recently established a program of resurvey on a municipal basis and projects are chosen based on provincial priorities with a publication scale of 1:50,000. The survey of Warner county was initiated in 1978 in response to specific concerns regarding soil salinity and erosion as well as the need to update the land resource base.

The earlier soil surveys conducted in this general area are the Lethbridge and Pincher Creek Sheets published in 1939, and the Milk River Sheet published in 1941.

ACKNOWLEDGEMENTS

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The following persons and organizations are recognized for their assistance and cooperation during the course of this project.

R. Leckie, M. Riddell and R. Shopik assisted in the field during mapping and sampling.

J. Beres, W.C. McKean and A. Schwarzer conducted the laboratory analyses.

Mrs. C. Lirette typed the report manuscript.

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Cartography Section, Land Resource Research Institute, Ottawa prepared the soils report and maps for printing.

Research Council of Alberta supplied the office and laboratory space. They also made available to us their files containing deep drill information, useful in determing depth to bedrock.

Irrigation Division, Alberta Agriculture, Lethbridge on several occasions made their deep drill and operator available to us. They also allowed us to have certain physical analyses done in their laboratory. Their continued cooperation and assistance particularly in regard to the irrigability of soils is appreciated.

SUMMARY

Warner County, covering more than 450,000 ha is located in southern Alberta on the Alberta-Montana border. It covers portions of 3 physiographic regions - the Eastern Alberta Plains, the Western Alberta Plains,and the Southern Alberta Uplands. Underlying bedrock formations are primarily of Upper Cretaceous age. One of these, the Milk River formation is spectacularly exposed along the Milk River in Writing-On-Stone Provincial park. Surface deposits are mostly till, deposited as an undulating moraine in the plains region and as a rough hummocky moraine in the upland areas. There are minor amounts of lacustrine and fluvial sediments.

The continental climate has warm dry summers and moderately cold winters modified somewhat by the occurrence of warm chinook winds from the west. Under these conditions the dominant ecological system is a mixed grass prairie.

Soils range in surface colors from brown and dark brown on the plains to black on the western side on the Milk River ridge. they are dominantly Chernozemic throughout the county with only minor amounts of Solonetzic, Gleysolic and Regosolic soils occurring.

About 2/3 of the county is cultivated, mainly in the plains region where grain production is the major enterprise. Irrigation is limited to the northwestern part. Livestock production dominates in the upland areas. Soil degradation is a major problem in the area, as evidenced by dryland salinity and soil erosion.

RÉSUMÉ

Le Comté de Warner, d'une superficie de plus de 450 000 hectares, longe, au sud de l'Alberta, la frontière du Montana. Il s'étend en partie sur trois régions physiographiques de la province: les plaines de l'est, les plaines de l'ouest et le bas-plateau du sud. Les formations du roc sous-jacent datent surtout du Crétacé supérieur. L'une d'elles, la formation de Milk River apparaît de façon spectaculaire le long de la riviére Milk dans le parc provincial Writing-On-Stone. Les formations superficielles sont constituées surtout de till, déposé sous forme de moraine ondulée dans la région des plaines et de moraine mamelonnée et accidentée dans celle du bas-plateau. Il y a aussi des sédiments lacustres et fluviatiles en moindre quantité.

Le climat, continental, se caractérise par des étés secs et chauds, et par des hivers modérément froids que modifie un peu le chinook, vent chaud qui souffle de l'ouest. Sous ces conditions, le système écologique dominant est la prairie mixte.

Pour leur couleur de surface, les sols varient du brun au brun foncé, dans les plaines, au noir, sur le flanc ouest de la crête de la formation Milk River. Partout dans le comté, ils sont surtout d'ordre chernozémique et, rarement, solonetzique, gleysolique et régosélique.

Enrion les deux tiers du comté sont cultivés, surtout dans la zone des plaines où la céréaliculture constitue la principale entreprise. L'irrigation se limite au nord-ouest. L'élevage domine dans le bas-plateau. La dégradation des sols est un problème majeur dans la région, notamment la salinisation des terres non irriguées et l'érosion.

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63-1	Preliminary
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64-2	Preliminary

Note: Reports published prior to 1942 are out of print but may be obtained on loan from the Alberta Soil Survey. These include: MacLeod sheet, Medicine Hat sheet, Sounding Creek sheet, Peace River, High Prairie, Sturgeon Lake area, Rainy Hills sheet, Sullivan Lake sheet, Lethbridge and Pincher Creek sheet, Milk River sheet, Rosebud and Banff sheets, and Wainwright and Vermilion sheets.

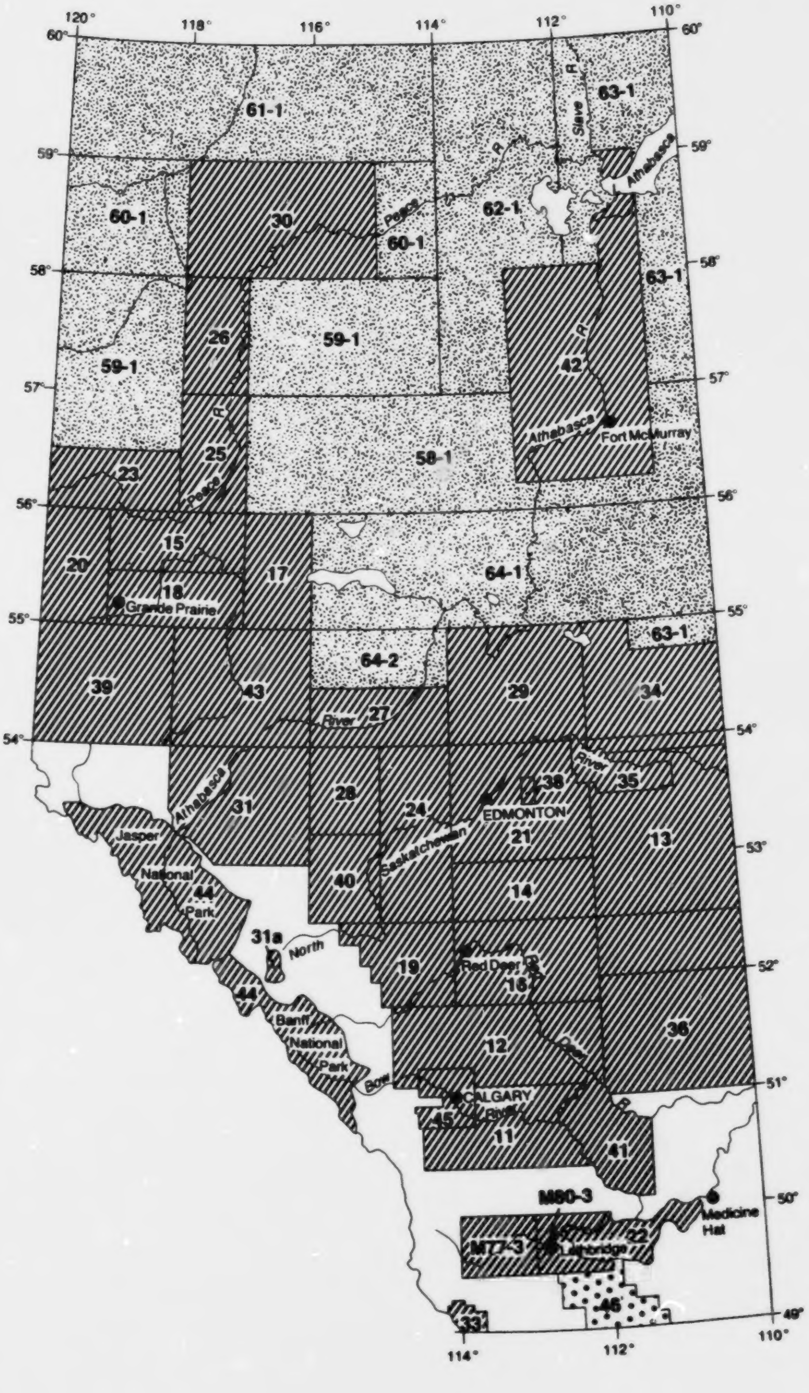


Fig. 1. Location map for soil survey areas in Alberta.

PART 1. GENERAL DESCRIPTION OF THE AREA

1.1. LOCATION AND EXTENT

The County of Warner is located southeast of Lethbridge, Alberta (Fig 1) where it borders on the 49th parallel with the United States of America. Its total extent of 453,760 ha lies within National Topographic Series Maps 82E and 82H.

1.2. HISTORY AND DEVELOPMENT

Southern Alberta had been continuously occupied by the Plains Indians for approximately 8,000 - 10,000 years based on scientific dating of buffalo jumps and butchering sites such as the one on the Fletcher farm just north of Chin Coulee near Skiff (24).

The first recorded visit by a white man in the area was by James Doty in 1855 who discovered the writings on the sandstone cliffs of the Milk River in the present day Writing-On-Stone Provincial Park (10). Another visitor was Captain John Palliser in approximately 1859 who was preparing a report on the agricultural potential of the prairie lands for the British Parliament.

By historical standards, the next 30 years was a period of rapid change. The white man began moving into the area, some as cattle ranchers but many as traders. Fort Whoop-Up was built in 1868 as a whiskey trading post and for the next six years a large supply of contraband goods were brought into the country by about 400 notorious lawbreakers travelling from Fort Benton, Montana (5). Most of this traffic followed the Whoop-Up Trail which entered Alberta at Red Creek about 10 km west of Coutts and followed the eastern shoulder of the Milk River Ridge before dropping to the plains level in the area south of Raymond.

With the arrival of the North West Mounted Police in 1874, the unrest and lawlessness soon abated. This allowed the force to set up frontier posts across the prairies including one at the mouth of Police Creek in Writing-On-Stone Provincial Park (16). This post was manned from 1887 to 1918 and acted as a central point for the force to watch for illicit traffic along about 160 km of the Canada-USA border.

In 1890, Sir Alexander Galt and his son Elliot, both of the Alberta Railway and Coal Company had a narrow gauge railway built from Coalbanks (now Lethbridge) to Coutts to join up with the Great Falls and Canada Railway on the U.S.A. side of the border (29). For about 12 years this railway which was commonly referred to as the Tea Kettle Line, was used for hauling coal to Great Falls, Montana with limited freight and passenger service provided. It was converted to standard gauge between 1903 and 1909 and with increased passenger train service it brought settlers to southern Alberta from the U.S.A. Real estate companies in Canada and the U.S.A. offered reduced fare packages for prospective buyers and homesteaders and by 1910 almost all of the land south of Etzikom Coulee was settled. During the Great Depression many farms were abandoned and were resettled in the 1940's and 1950's. Most of the land within the Milk River Ridge has remained in native range and is largely crown lease land.

According to the 1981 Census (1), the total population in the County of Warner is 8,789 with the farm population comprising 29%. The major population centres include Raymond (2672), Milk River (814), Stirling (664), Warner (468), and Coutts (407).

Rail service is supplied by two CPR lines, one from Lethbridge to Coutts, the second an east-west line passing through Raymond and Stirling and proceeding on to Foremost. The area is serviced by Highway No.4, a main access route to the U.S. through Coutts. East-west highways include No.61 proceeding east from Stirling, and No.52 passing through Raymond. Good secondary roads are found at convenient intervals throughout the county, except on the Milk River Ridge where access is limited.

1.3. CLIMATE

The continental climate of Warner County is similar to that of the rest of the western plains. It features short, warm summers, however the severity of winter is somewhat reduced due to the proximity of the mountains to the west and frequent chinook winds. The local climate is further influenced by the Milk River Upland and the Sweetgrass Hills. Climatic changes are reflected in the surface colors of soils found within the area. They range from brown to dark brown to black (Fig. 2) in response to increased precipitation.

Meteorological data (12) for stations in Milk River and Warner as well as for nearby stations (Table 1), characterize climatic conditions within the area. For purposes of comparison, data from Medicine Hat and Calgary are also included in Table 1.

Precipitation normals for a thirty year period (Table 1), show that the area receives between 316 and 450 mm of precipitation annually. The lowest precipitation falls in the Brown Soil Zone while the highest in the Black Soil Zone on the Milk River Upland.

Snow contributes about 30% of the annual precipitation. The highest average snowfall occurs in January, however, the greatest single snowstorms often occur in March or April, thus posing considerable risk to livestock.

The mean annual temperature in the county ranges from 5.8°C at Aden to 3.8C at Whiskey Gap (Table 1). A comparison of data shows that despite higher elevations, the area is a little warmer than comparable areas east or north of the county. This is mainly due to warmer winter temperatures resulting in part from the chinooks.

The frost free period on the plains is generally greater than 120 days (Table 1). The last spring frost occurs about mid-May and the first fall frost comes about mid-September (12). The shorter frost free period on the Milk River Upland, which is less than 90 days, makes the area more suitable for coarse grains and grazing than for wheat production.

The May to September precipitation accounts for more than 50% of the annual total, which is very favorable for crop production. This is however offset by its high yearly variability and uneven distribution within the area. Figure 3 illustrates the wide fluctuation in rainfall that can occur. It also accents the fact that the danger of water erosion is a reality in Warner County, particularly during heavy rains (Fig. 4).

In order to obtain information on soil temperatures, 4 locations were instrumented in 1978 and temperatures monitored for three years. Data (Table 2) show marked differences in soil temperatures across the soil zones. The upper 10 cm of soil, which is the seeding depth, thaws in early March in the Brown Soil Zone. In the Dark Brown Soil Zone thawing temperatures are reached in mid March, and in the Black Soil Zone they are not reached until near mid April. Freezing depths were between 50 and 100 cm in all three zones.

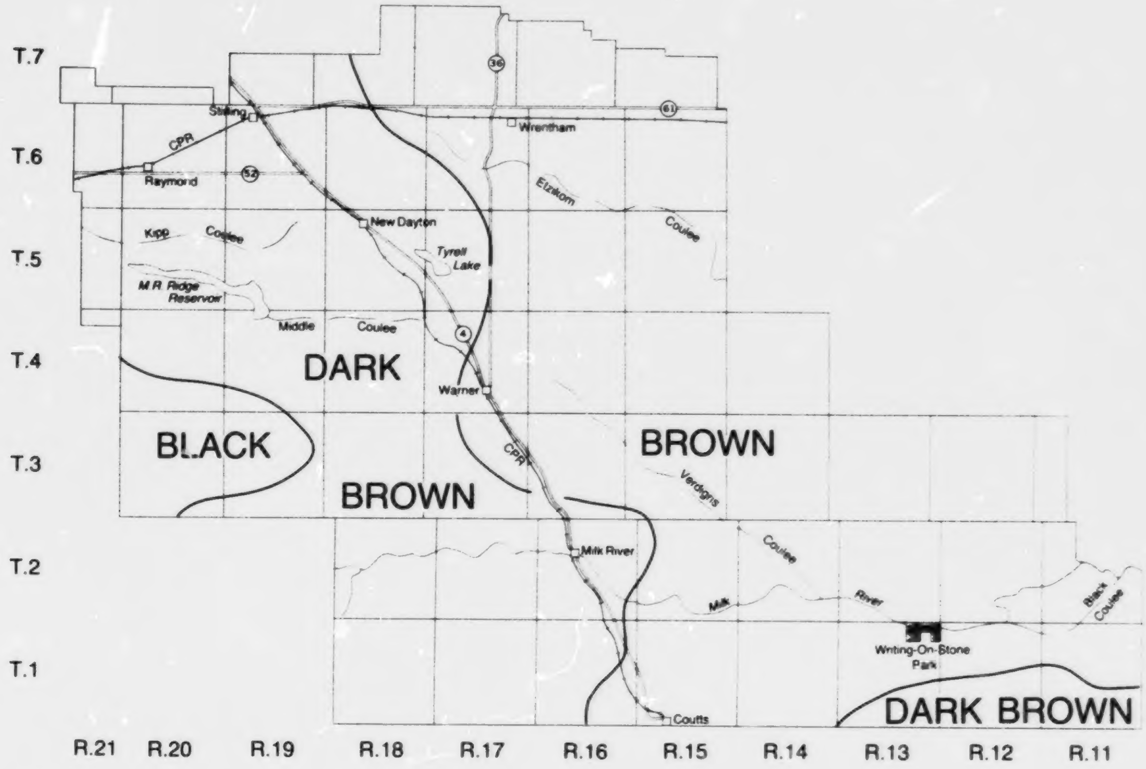
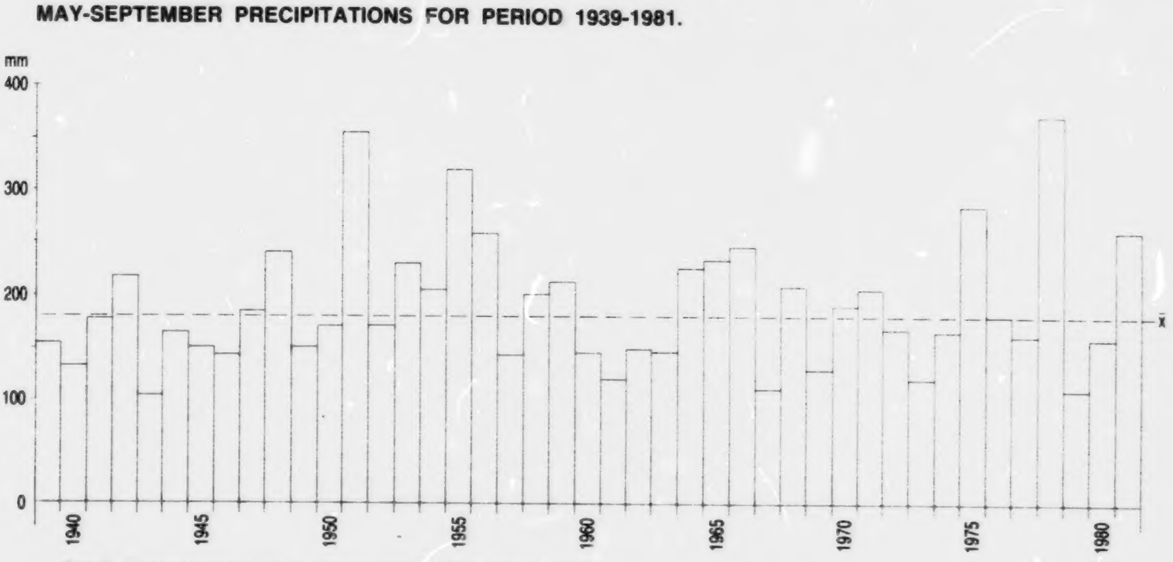


Figure 2. Soil zones in Warner County.



Source: Personal communication, Andrew and Richard Thull (NE 3-3-14-W4)

Figure 3. May to September precipitation east of Milk River (1931-1981).

Table 1. Precipitation and temperatures for selected stations, 1951-1980(12)

Station and elevation	Soil Zone	PRECIPITATION mm			TEMPERATURE °C			Frost free period (days)
		Mean Annual	May Sept.	Snow	Jan.	July	Mean Annual	
Medicine Hat 717 m	Brown	348	180	126	-12.6	19.9	5.1	129
Foremost 884 m	Brown	356	182	116	-11.6	18.9	4.8	129
Milk River (Masinasin) 975 m	Brown	316	172	84	-10.8	18.9	5.2	124
Warner 1010 m	Brown	367	187	127	-	-	-	-
Lethbridge Airport 929 m	D. Brown	423	220	158	-10.3	18.6	5.3	124
Magrath 978 m	D. Brown	-	241	-	- 9.6	18.3	5.4	116
Aden 1036 m	D. Brown	393	184	151	- 9.5	19.1	5.8	129
Whiskey Gap 1311 m	Black	453	250	175	- 9.6	15.8	3.8	88
Calgary Airport 1084 m	Black	424	259	153	-11.8	16.4	3.4	112

Table 2. Mean soil temperatures at four selected sites (1978-1981)

Depth (cm)	Site*	Soil Zone	Elevation (m)	January °C	July °C	Annual °C	Summer °C
10	1	Brown	975	-2.9	21.5	8.3	19.4
	2	D. Brown	990	-3.3	20.8	7.1	18.7
	3	D. Brown	1210	-1.0	17.4	7.1	16.5
	4	Black	1285	-2.0	14.8	5.5	14.0
20	1			-2.6	19.7	7.8	17.4
	2			-1.9	18.3	7.3	16.6
	3			-1.0	13.9	5.7	12.9
	4			-1.7	12.8	4.9	12.1
50	1			-2.3	16.5	7.2	15.0
	2			-1.3	15.0	6.8	14.1
	3			0.7	12.0	6.1	11.5
	4			0.0	11.4	5.2	10.5
100	1			1.3	13.0	7.4	12.5
	2			2.8	12.8	8.0	12.7
	3			2.3	10.1	6.1	9.9
	4			0.9	8.2	4.2	7.7

* Site 1 SE25-4-16-W4
Site 2 NC23-5-20-W4
Site 3 NE17-4-20-W4
Site 4 WC 9-4-20-W4

Southern Alberta is known for its frequent strong winds. Data for the Lethbridge airport (12) show that there are only 15 calm days annually, compared to 27 in Medicine Hat. Prevailing westerly winds are most evident during the period from October to December. The average annual wind speed is 20.4 km/hr with maximum hourly speeds of 121 km and maximum gusts of 171 km/hr. As a result, wind erosion is a very real problem in this area (Fig. 5).

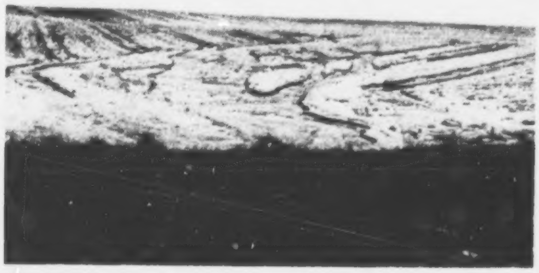


Fig. 4. Rill erosion on a 5% slope.

Fig. 5. Wind erosion, a very real problem.

1.4. VEGETATION

The County of Warner is located almost entirely in the Mixed Prairie Grassland Association. The Fescue Grassland Association, which comprises about 5% of the total area, is located on the Milk River Ridge at an elevation greater than 1250 m. It is associated with Black soils and is characterized by pure stands of rough fescue, if the range is not overgrazed.

There are two major grass types and two minor ones representing the Mixed Prairie Association. One major type consists of needle and thread, blue grama, and northern and western wheatgrasses. It occurs in the Brown Soil Zone which comprises about 45% of the county, and is associated with medium textured soils belonging to the Chernozemic Order.

The other major type occurs on medium textured Dark Brown Chernozemic soils and covers about 40% of the county. It consists of western porcupine grass and wheat grasses. However, most of this unit is presently under cultivation.

One minor type consists of blue grama and western wheatgrass which occur on Solonetzic soils of both the Brown and Dark Brown Soil Zones. Wheatgrasses commonly grow in the blowout pits and blue grama in the interpit areas. The other minor type is sagebrush and western wheatgrass which is commonly found on low-lying saline flats such as those in Verdigris Coulee. Although this latter type also occurs in Black Coulee, where greasewood is more prevalent.

Other vegetation types will occur in miscellaneous situations such as coulee slopes with prickly pear cactus, blue grama and little club moss. In several locations in the Milk River valley and its side coulees, thorny buffaloberry, saskatoon and western cottonwood may be found. Rose bushes and goldenbean are common on the coarser textured soils. Wetland and badland landscapes have their own unique vegetative characteristics.

For more complete species information the reader is referred to Section 3.4.

1.5. PHYSIOGRAPHY, RELIEF AND DRAINAGE

The County of Warner encompasses three physiographic regions, the Eastern Alberta Plain, the Western Alberta Plain, and the Southern Alberta Uplands. These regions are further divided into sections and districts shown in Table 3, based primarily on elevation and major landform characteristics. Their location is shown in Figure 6.

Chin Plain (Plate 1-A) is an undulating morainal area with significant areas of lacustrine veneer over till. The elevation of this plain is about 900 m. An elevation of 830 m in Chin Coulee is the lowest point in the County of Warner.

Verdigris Plain is characterized by a partially dissected landscape of morainal material overlying rolling bedrock. Significant areas of lacustrine veneer overlying till also occur. A local high of 1100 m occurs approximately 2 km east of Coutts on the 49th parallel. At the point where the Milk River flows out of the county the elevation is 880 m, the lowest elevation in this district.

The highest elevation in the county, 1340 m, occurs in the Milk River Ridge District about 1 km east of the southwest corner of the county. This district is dominated by a hummocky till landscape in which sloughs often occur. Frequent dissections also occur, especially on the north slope leading to the plains below the ridge (Plate 1-B).

The Milk River Plain is characterized by hummocky morainal landforms as well as undulating and terraced fluvial materials. Elevations in this district are significantly lower than those of the Milk River Ridge.

A hummocky and dissected morainal landform overlying inclined bedrock, typifies the Sweetgrass Upland (Fig. 7). It forms the north shoulder of the Sweetgrass Hills which reach an elevation of 2100 m in Montana.

Generally going from northeast to southwest, elevations and relief gradually increase until the Milk River Ridge is reached. There, an abrupt increase occurs in both elevation and relief. These changes are reflected in the topographic slope characteristics that prevail in various parts of the county (Fig 8). The areal extent of the various slope classes (topography) is summarized in Table 4.

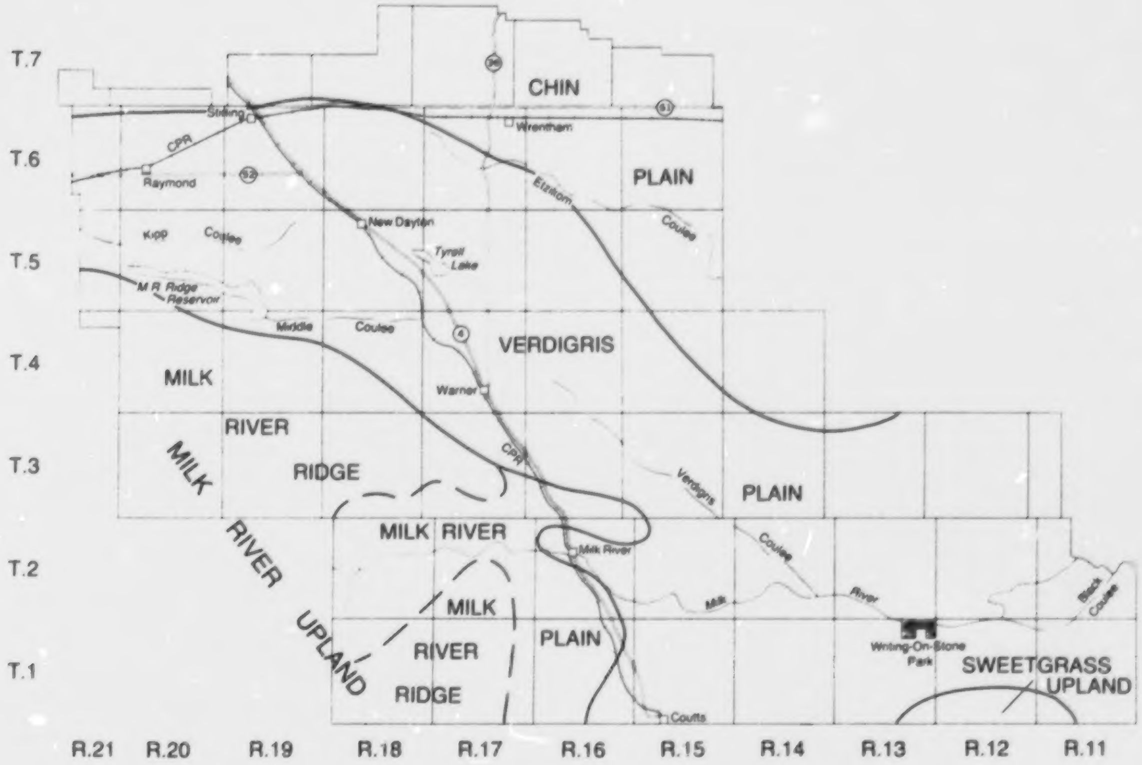


Fig. 6. Physiographic units in Warner County.

TABLE 3. Physiographic characteristics of Warner County*.

Region	Section	District	Landform
Eastern Alberta Plains	Coulee Plain	Chin Plain 890-980 m	undulating moraine
Western Alberta Plains	Southwest Plains	Verdigris Plain 920-1070 m	morainal over rock
Southern Alberta Uplands	Milk River Upland	Milk River Ridge 1070-1340 m	hummocky moraine, dissected
		Milk River Plain 1040-1220 m	humocky morainal and fluvial
	Sweetgrass Upland	Sweetgrass Upland 1040-1290 m	hummocky moraine, dissected

* Source: Physiographic Map of Alberta in preparation by Agriculture Canada Soil Survey.

TABLE 4. Extent of each slope class in Warner County.

Slope Class	Slope Range %	Hectares	% of Total
1 & 2	<2	46,000	10.1
3	2-5	219,640	48.4
4	6-9	106,100	23.4
5	10-15	38,200	8.4
6	16-30	6,760	1.5
Undifferentiated		37,060	8.2

The major portion of Warner county is drained by the Milk River and its tributaries which eventually flow southward into the Mississippi River drainage system. In the northwest part of the county drainage is into the St.Mary's River, which together with Chin Coulee, drain into the Saskatchewan River system. Some drainage is provided by Etzikom Coulee which is part of an internal system draining into Pakowki Lake about 65 km to the east. Although coulees (Plate I-D) are a distinct feature, they are not of great significance to the drainage of this area.

Fig. 7. Slopes to the Sweetgrass Hills.

1.6. BEDROCK GEOLOGY

Bedrock formations in Warner County are almost exclusively of Upper Cretaceous age. The exception is a small area in T.1 R12 where a Tertiary formation of pale greenish gray acidic porphyry occurs. Figure 9 shows the extent and location of the 6 bedrock formations that occur (9, 14). They are described (3) as follows:

BEARPAW FORMATION: dark gray blocky shale and silty shale; greenish glauconite and gray clayey sandstone; thin concretionary ironstone and bentonite beds; marine

OLDMAN FORMATION: pale gray, thick-bedded, medium to coarse-grained, feldspathic sandstone; gray clayey siltstone; green and gray mudstone, dark gray and brown carbonaceous shale, concretionary ironstone beds; nonmarine

FOREMOST FORMATION: pale gray feldspathic sandstone, gray and green siltstone; greenish gray mudstone and dark gray carbonaceous shale; concretionary ironstone beds; thin coal beds; nonmarine

PAKOWKI FORMATION: dark gray shale and silty shale; minor sandstone; thin chert-pebble conglomerate or pebble bed at base; marine

MILK RIVER FORMATION: pale gray, thick-bedded, feldspathic sandstone with hard calcareous beds; pale to dark gray shale and silty shale; ironstone concretions; marine and nonmarine

ALBERTA GROUP: dark gray fissile shale and silty shale; minor gray cherty sandstone; marine

Near surface exposures of bedrock are common along banks of streams and coulees cut into the Milk River formation. These are visible along the Milk River downstream from the mouth of Red Creek, extending eastward a few kilometres beyond Writing-On-Stone Provincial Park. In this park, sandstone cliffs and hoodoo formations present a very unique and spectacular picture of natures handiwork (Plate 1-C).

Rough broken banks along Verdigris Coulee also have extensive exposures of the Milk River Formation. The upper, more shaly member is particularly noticeable where secondary Highway 501 crosses the coulee 18 km east of Milk River. At a point about 3 km southeast of this crossing, there is a distinct change in the character of the coulee banks, from bare slopes to grassy slopes (Fig. 10). This is believed to be the approximate location of the interface between the upper and lower members of the Milk River Formation.

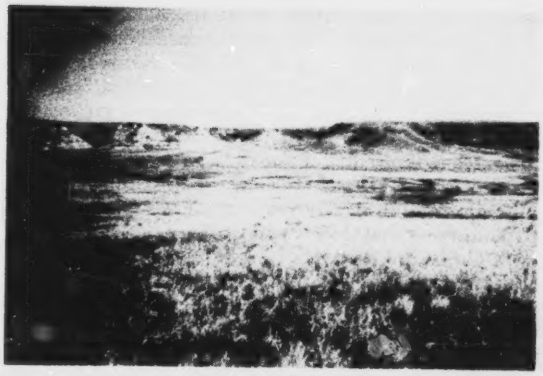


Fig. 10. Upper (left) and lower (right) Milk River formations along Verdigris Coulee. McNab soils in foreground.

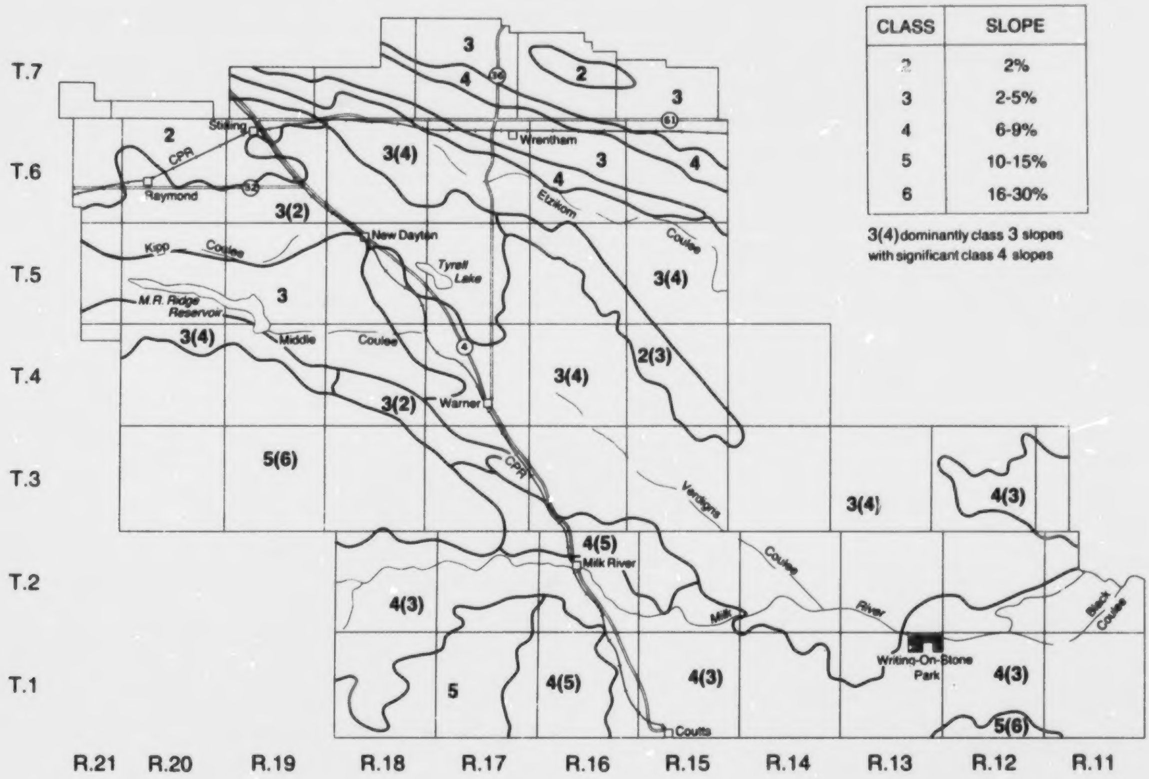


Fig. 8. Generalized slope class map for Warner County.

1.6.1 Depth to Bedrock

A good knowledge of depth to bedrock is desirable for better assessment of the soil's agricultural potential, especially for irrigation. Both depth to, and kind of bedrock are known to influence ground water movement thus imposing a possible limitation on soil utilization.

Geiger (13) and Westgate (32) described the bedrock topography of Warner County in studies of surficial geology in southern Alberta. Since the hundred foot contour interval on their bedrock maps is not detailed enough for agricultural interpretations, more information was collected from deep drill transects (Fig. 11) conducted during the Warner County soil survey. This was augmented by drill logs from a local well driller and data gathered by the Irrigation Division of Alberta Agriculture in Lethbridge. Additional information on depth to bedrock was obtained from the Groundwater and Geology Departments of Alberta Research Council in Edmonton. From this information a generalized map was prepared (Fig. 12) showing depth to bedrock. It indicated that soils with bedrock at less than 10 m from the surface form a broad, northwest-southeast, strip, 10-25 km wide, paralleling the base of the Milk River Upland. This area corresponds roughly with, and lies almost entirely within Verdigris Plain. Southern limits of this area includes the lower northern slopes of both the Milk River Upland and the Sweetgrass Upland. Its northern limit approximates the borders of the Etzikom and the Pakowki moraines. Within this area, there are many areas with bedrock at less than 5 m or even 3 m (Fig. 13).

Fig. 13. Bedrock is shallow in many parts of Verdigris Plain.

It is also worth noting that all major areas of dryland salinity occur in the area having bedrock within 10 m of the surface. Thus it appears that the proximity to bedrock controls the discharge of shallow ground water*. By comparison, dryland salinity is of minor occurrence on the deeper till deposits of Chin Plain particularly north of Etzikom Coulee even though the till materials are somewhat saline. Conversely, no dryland salinity occurs on the Milk River Upland where the underlying bedrock is a saline shale, but till deposits are considerably more than 10 m thick.

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* Personal communication, Groundwater Department, Research Council of Alberta

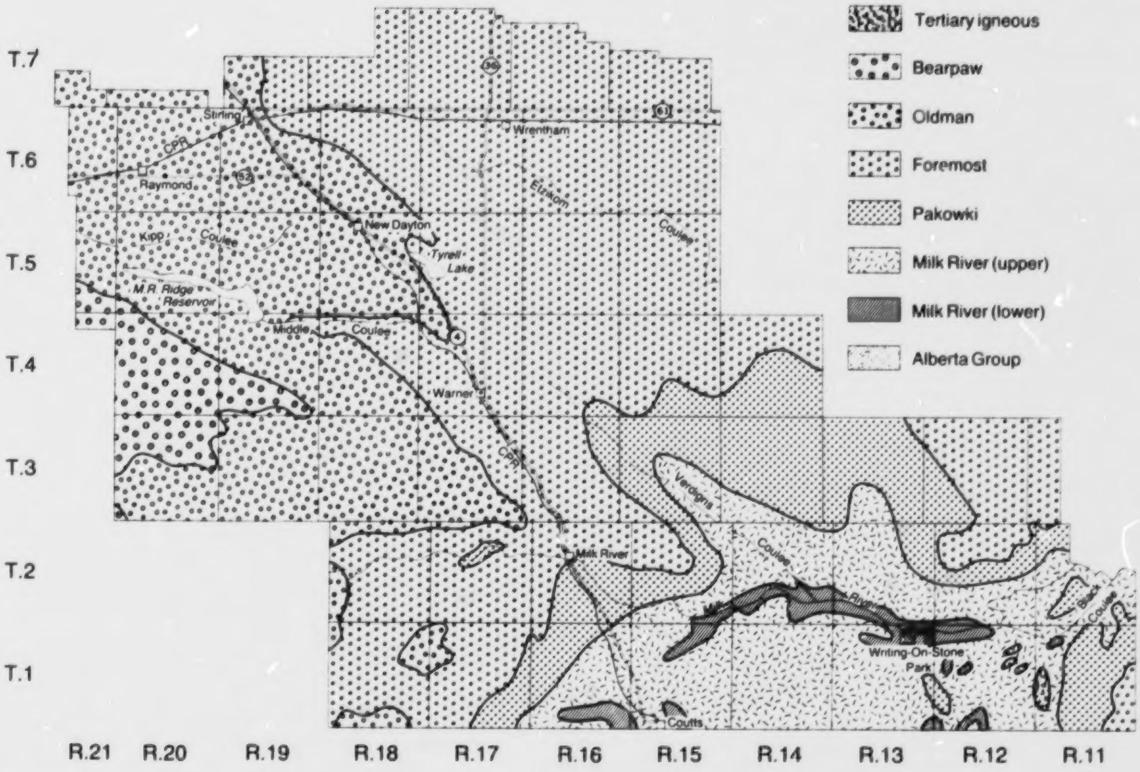


Fig. 9. Bedrock formations in Warner County.

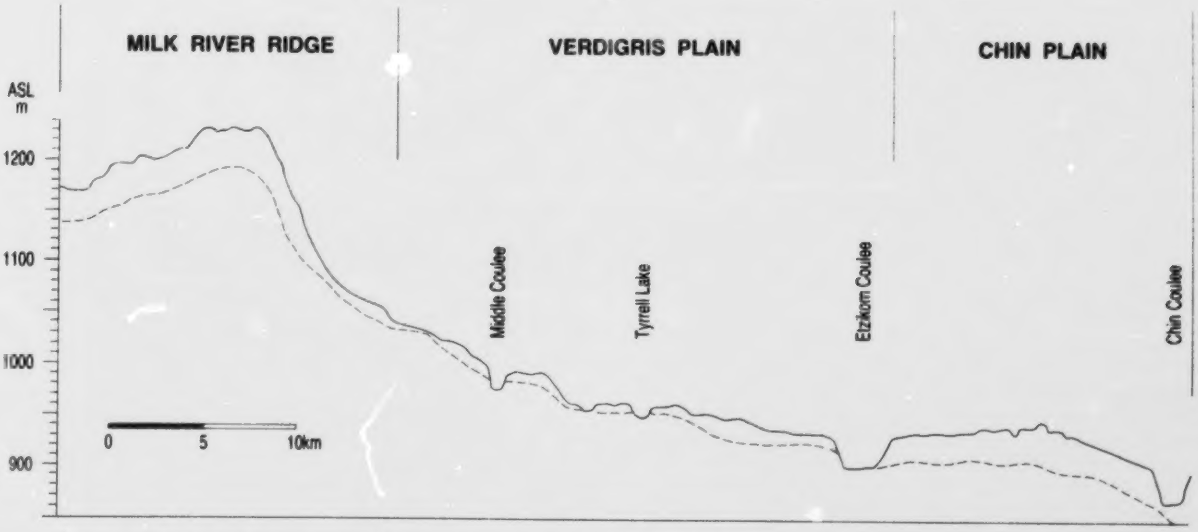


Fig. 11 Bedrock depth cross section from Chin Coulee to the Milk River Ridge.

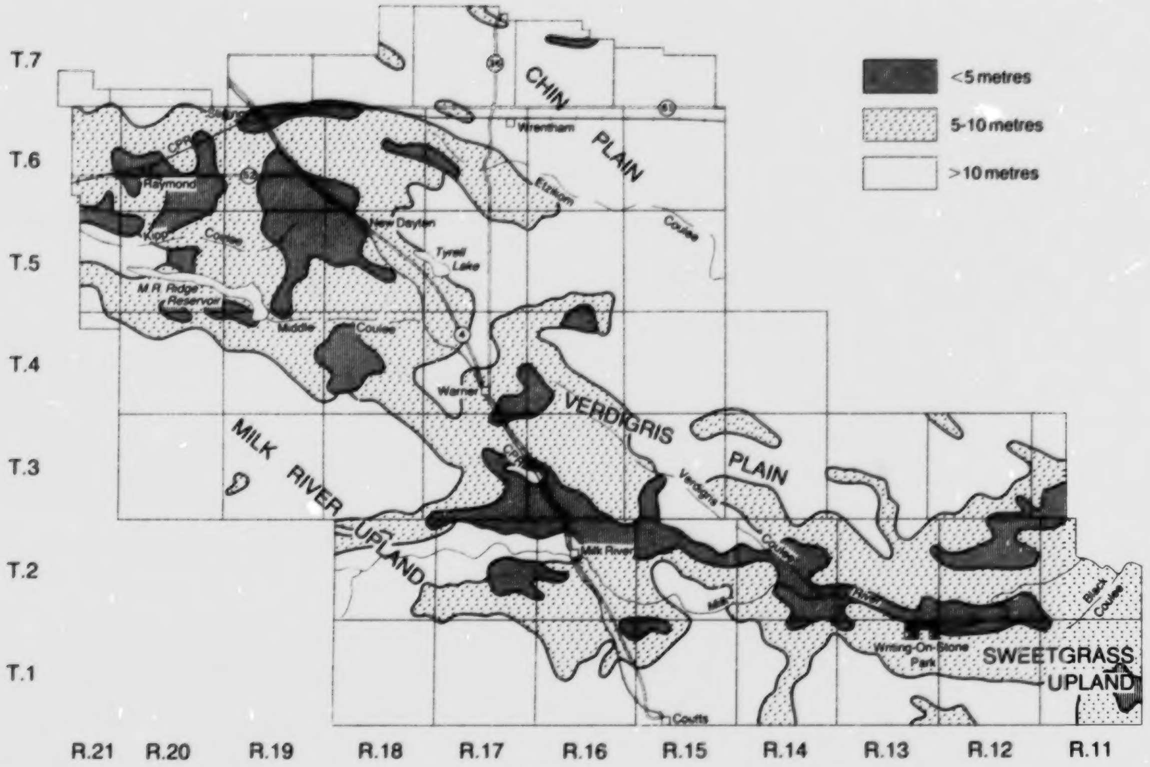


Fig. 12. Generalized map showing depth to bedrock.

1.7 SURFICIAL DEPOSITS

The surficial geologic features in Warner County are primarily the result of glaciation. It is believed that glaciers of both Cordillerian and Laurentide origin modified the surficial materials. Laurentide glaciers are known to have covered the entire area. However, the extent of the Cordilleran glaciers is a matter of conjecture. Where found, the Cordilleran deposits, underlie those of Laurentide origin. Stalker (27) has identified 4 distinct Laurentide tills which could be the result of 4 glacial advances, the last being approximately 15000 years ago.

More than half of Warner County has till surface deposits (Table 5, Fig. 14). Other deposits of more limited extent include lacustrine materials deposited in standing water, as well as fluvial and ice-contact materials. The largest concentration of lacustrine deposits occur in the northwestern part of the county. Fluvial deposits, ranging in texture from sandy loam to outwash gravels are deposited in moving water. Thus, as expected the largest concentration of fluvial materials is associated with the Milk River. Ice-contact deposits, which are variable, often gravelly materials deposited in contact with melting glacier ice, are found only on the Milk River Ridge.

A number of dolomitic erratics of varying size were observed on the Milk River Ridge. One of the larger ones (Fig. 15) occurring in NE21-1-18 is part of a northwest-southeast erratics train in that township.

Fig. 15. A dolomitic erratic on the Milk River Ridge.

TABLE 5. Extent of surficial deposits in Warner County.

Material	Hectares	% of total
Till		
non saline	264,110	58.3
slightly saline	67,620	14.9
Total till	331,730	73.2
Ice-contact material	5,640	1.2
Lacustrine		
fine textured	15,140	3.3
medium textured	39,200	8.6
Total lacustrine	53,350	11.9
Fluvial		
sandy loams	14,990	3.3
loamy sands	8,320	1.8
outwash	1,900	0.4
Total fluvial	25,210	5.5
Undifferentiated (RB, W, DL, Towns)	37,060	8.2

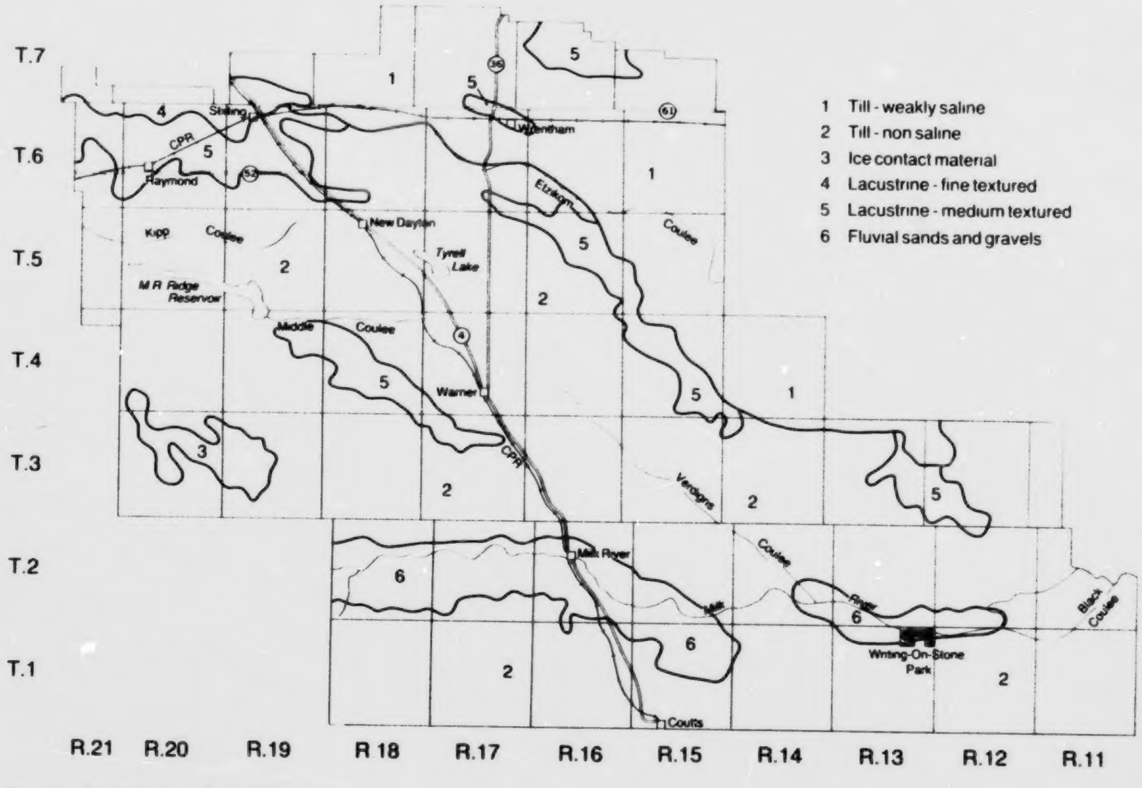


Fig. 14. Surface deposits in Warner County.

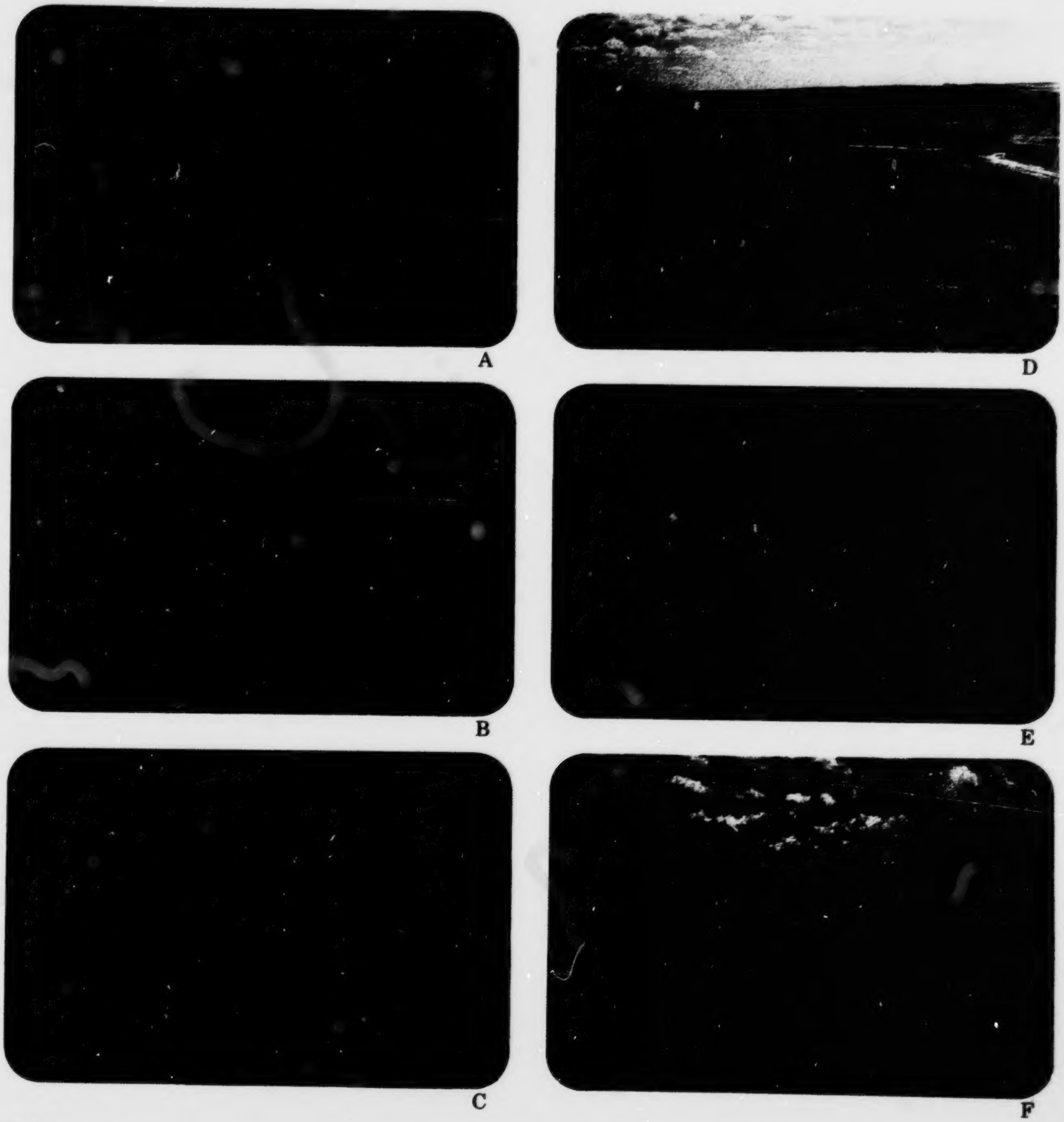


Plate I

A. Verdigris Plain viewed from the Milk River Ridge.
B. Dissected landscape on north slopes of the Milk River Ridge.
C. Hoodoo formations in Writing-On-Stone Provincial Park, an RB3 unit.
D. Coolees are a distinct feature in Warner County.
E. Undulating ground moraine the dominant landform in Warner County.
F. Sloughs in a hummocky morainal landform.

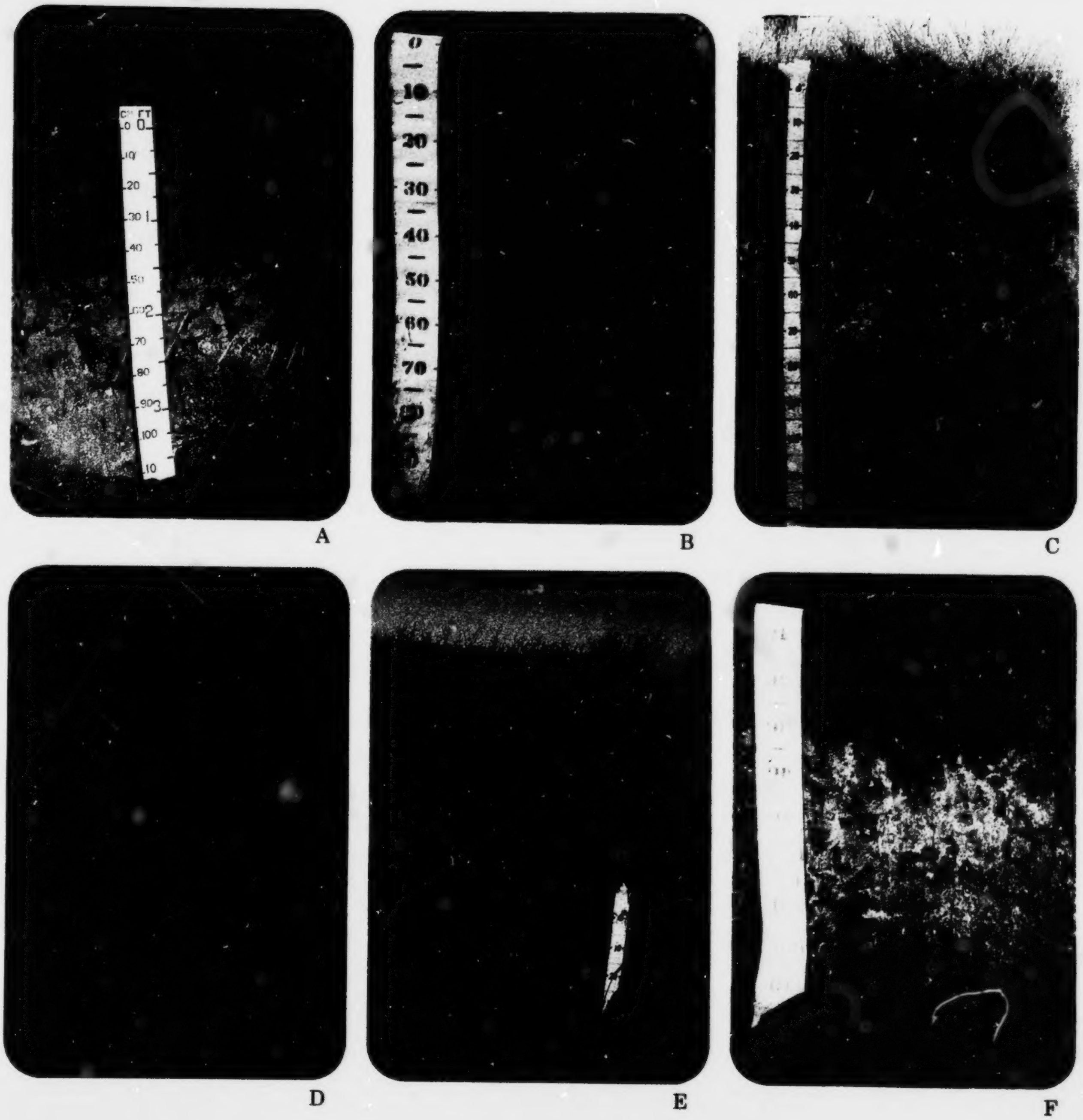


Plate II

A. A Bunton soil profile.
B. A Beazer soil profile.
C. A Cranford soil profile.
D. A Cradduck soil profile.
E. Kochia weeds on a Lillydale soil.
F. A Maleb soil profile.

PART 2. THE SOILS

2.1 SOIL FORMATION

Soil is the product of climate, vegetation, and topography acting on the parent material over a period of time and more recently influenced by activities of man. The degree and variability of any or all factors and their interaction is reflected in the numerous kinds of soils that exist in any given area. Climatic influences are mainly through precipitation and temperature as well as wind and water erosion. Furthermore, climate determines the type of vegetative cover and degree of biological activity. Different plant species produce different kinds and amounts of residues which in turn determine soil color. Topography governs drainage and moisture conditions thus producing microclimatic variations which in turn produce variability in vegetative cover. Another major influence on soil formation is exerted by the parent material especially with respect to its inherent variability in such characteristics as texture and mineralogy.

Weathering processes produce many varied but observable and measurable soil characteristics such as color, structure, texture, and consistence, to name the more important ones. Color itself has little direct influence on the functioning of the soil, but a great deal can be inferred from color when considered with other observable features. Dark colors are the result of high organic matter content and indicate relatively high natural fertility. Reddish colors are the result of hydrated iron oxide and are usually associated with good drainage and well aerated soils. Shades of gray, brown, or yellow, in a mottled arrangement are usually associated with soils of poor drainage. Soils with light gray colors are usually lacking in organic matter, indicating low fertility.

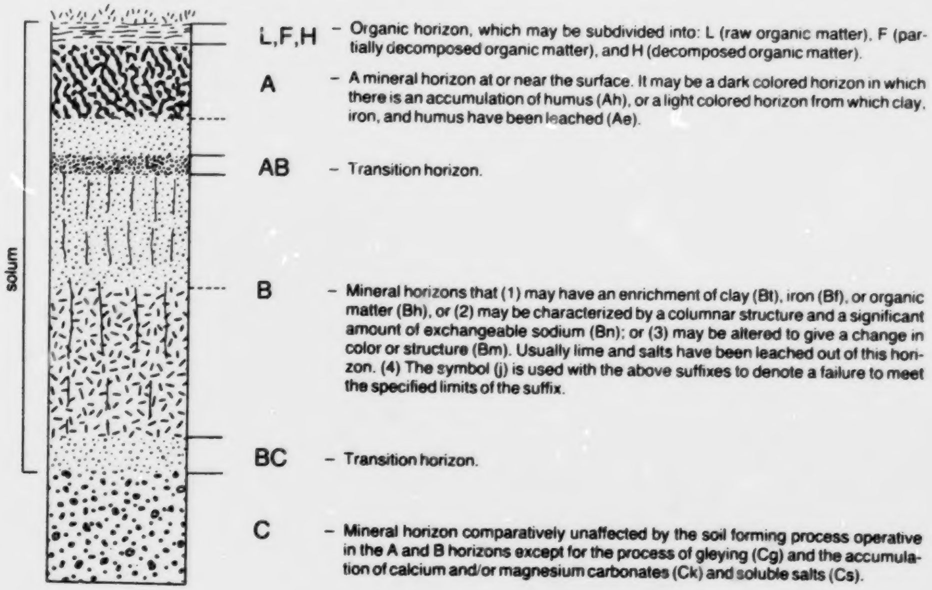
Soil structure (the way soil particles aggregate) is important as it influences the movement of water and air and also the workability and tilth of cultivated soils. Other physical characteristics such as texture and moisture content, as well as chemical characteristics, help determine the type of structure in any given soil. Soil consistence (the ability of a soil to resist structural breakdown) is also important as it relates to various management practices.

These, and other features (clay films, concretions, carbonates, salts, reaction, coarse fragments, roots, and pores) of the soil profile can be observed and measured, both quantitatively and qualitatively, and form a record of the kind and degree of weathering that has occurred. Soils can be divided horizontally into horizons based on the fact that weathering becomes less pronounced with depth. This is referred to as the soil profile and is the basis of the soil classification system. Figure 16 depicts the major horizons into which a soil profile can be divided.

2.2. SOIL CLASSIFICATION

Soil classification is the orderly arrangement (or grouping) of soil characteristics according to the processes involved in their formation as displayed by the soil profile. In the soil survey of Warner County soils were classified according to the guidelines established by the Canadian System of Soil Classification (6). The basic unit in soil classification is the soil series which consists of soils which are alike in all major profile characteristics.

For a better understanding of the soils, a brief description is included here of the four soil orders mapped in the county, listing the more important characteristics of each.



L,F,H – Organic horizon, which may be subdivided into: L (raw organic matter), F (partially decomposed organic matter), and H (decomposed organic matter).

A – A mineral horizon at or near the surface. It may be a dark colored horizon in which there is an accumulation of humus (Ah), or a light colored horizon from which clay, iron, and humus have been leached (Ae).

AB – Transition horizon.

B – Mineral horizons that (1) may have an enrichment of clay (Bt), iron (Bf), or organic matter (Bh), or (2) may be characterized by a columnar structure and a significant amount of exchangeable sodium (Bn); or (3) may be altered to give a change in color or structure (Bm). Usually lime and salts have been leached out of this horizon. (4) The symbol (j) is used with the above suffixes to denote a failure to meet the specified limits of the suffix.

BC – Transition horizon.

C – Mineral horizon comparatively unaffected by the soil forming process operative in the A and B horizons except for the process of gleying (Cg) and the accumulation of calcium and/or magnesium carbonates (Ck) and soluble salts (Cs).

Fig. 16. Diagram of a soil profile showing major horizons

Chernozemic Order:
1 - has organic-rich surface horizon (2-5% organic carbon in Warner)
2 - has a C:N ratio of less than 17 in the A horizon
3 - has a high base saturation in the A horizon
4 - calcium is the dominant exchangeable cation
5 - has a brownish colored solum
6 - all horizons are relatively friable
7 - is well to imperfectly drained
8 - developed under a Stipa-Bouteloua-Agropyron grassland community
9 - the mean annual soil temperature is between 00C and 80C

Solonetzic Order:
1 - has a hard and impermeable B horizon
2 - has a strong columnar or prismatic structure in the B horizon
3 - has a dark coating on peds in the B horizon
4 - has a Ca:Na ratio of 10 or less in the B horizon
5 - usually has a neutral to acid A horizon
6 - is associated with saline parent materials high in Na
7 - has developed under a Bouteloua-Agropyron grassland community

Regosolic Order:
1 - has weak to no profile development
2 - has no structural development
3 - is rapidly to imperfectly drained
4 - has a variable vegetative cover

Gleysolic Order:
1 - occupies depressional position in the landscape
2 - has dull soil colors with mottles indicative of gleying
3 - soil horizons are often indistinct
4 - has hydrophytic vegetation

2.3 MAP SYMBOLS AND LEGEND

The purpose of soil mapping is to divide the landscape into units or areas which differ from one another in some significant aspect, with particular attention being placed on soil and landscape features. These units, called map units are shown on the soil maps as unique areas bounded by a soil line and identified by a map unit symbol. The map unit is defined in terms of the soil and landscape features which it represents.

The unit symbols used in this report have two major components, in a fraction format. The numerator represents the soil component and the denominator the landform component. Since all the information gathered during the course of a soil survey cannot be shown on the published map, a simplified map symbol is used. Typical symbols are:

a) $\frac{\text{MSN1}}{4}$ b) $\frac{\text{MSCF7}}{3}$.

The main part of this symbol is the soil series. It has been a long standing practice to identify soil series by a name which is usually derived from a named feature (town, post office, river, lake, etc.) in the vicinity where the series was first identified. Each established series is given a unique 3 letter symbol, such as MSN for the Masinasin series. When a soil area has been outlined which is dominantly the Masinasin series, that area is identified by the dominantly occurring series (for example MSN1).

However, since soil areas are not always composed entirely of one series it becomes necessary to devise a method whereby the variability can be shown. In this survey variability was grouped into three general kinds, each depicted in the soil unit part of the map symbol in a specific manner. The three kinds of variability are:

a) a complex (or combination) of two series. For such areas, the soil unit symbol combines the first two letters of the two series into a 4 letter symbol. A Masinasin-Cranford (CFD) area is identified by the MSCF symbol.

b) areas with significant amounts of other kinds of soils. Such units are handled by adding a numeric suffix to the series symbol. Six kinds of variations were recognized in addition to the relatively pure unit.

1 - a relatively pure unit (MSN1)
2 - significant amounts of Gleysolic soils (or sloughs) (MSN2)
3 - significant amounts of saline soils (MSN3)
4 - significant amounts of Rego and/or Calcareous Chernozemic soils (MSN4)
5 - significant amounts of finer textured soils (MSN5)
6 - significant amounts of coarser textured soils (MSN6)
7 - significant amounts of Solonetzic soils (MSN7)

c) areas in which a certain soil phase of the dominant series is prevalent. In these units the last letter of the series symbol is substituted with a colon and the appropriate phase symbol followed by the numeric suffix. Five phases were recognized:

1 - eroded phase, symbol E (Ms:E1)
2 - gravelly phase, symbol G (MS:G1)
3 - lithic phase, symbol L (MS:L1)
4 - stony phase, symbol P (MS:P1)
5 - saline phase, symbol S (MS:S1)

This method of depicting the soil unit (or numerator) portion of the map unit symbol makes it possible to symbolize a wide variety of soil conditons.

As mentioned, the denominator portion of the map unit symbol describes the landform within a given area. In this survey, only the topographic characteristics of the landform have been included in the map unit symbol. Other landform characteristics such as surface form and mode of deposition are described in the legend accompanying the soil map, as well as in the map unit descriptions.

Topographic characteristics are described by using the appropriate slope class number for the various slope classes as presented in Table 4. In addition some areas have underlying bedrock within 5 m of the surface. Where this occurs the slope class number is followed by a colon and R, the symbol used for bedrock (3:R).

The symbology described above is unique to the soil survey of Warner County. Although similar map unit symbols are being used elsewhere in Alberta, the numeric suffixes in particular can have different definitions in other projects. The number and definition of these numeric suffixes is dependant on the variability of soil characteristics in the project in which they are used, and are unique to that project.

The soil legend as it appears with the soil maps is an extension of the map unit symbols. It presents basic information on both soil and landform characteristics. However, it does not include any minor soils (usually referred to as inclusions) which only form 10 to 15% of most map units. If inclusions of any significance occur they are included in the map unit descriptions. These inclusions do not affect the use interpretations for any given map unit.

2.4 MAPPING PROCEDURES

During soil mapping all roads and trails in the county were traversed. At about 0.8 km intervals along each traverse, soils were examined to a 1 m depth using a shovel and hand auger. Soil and landscape characteristics were recorded for each inspection site. Frequent departures by foot from the lines of traverse were also necessary to determine soil and landscape features between traverses. As the survey progressed, soil and topography boundaries were determined along the lines of traverse and projected between them using visible landscape features and stereoscopic examination of aerial photographs. These boundaries were drawn on a field map consisting of an aerial photograph of the township, enlarged to a scale of approximately 1:32000. Map delineations were identified with the appropriate map unit symbol. Each completed township soil map was compared, checked and correlated with those of adjoining townships.

During the course of the survey, soil samples were collected and analysed to further characterize the soils. In order to gain information below the 1 m depth, especially depth to bedrock, deeper drilling was conducted on a few selected transects. Additional information was also obtained from other investigators as well as from farmers and local residents.

When all field data had been gathered, checked and correlated, the soil boundaries and their map unit symbols were transferred to the final maps, covering the county at a scale of 1:50,000. Thus all the data obtained during the 3 summers of field work was condensed into the map legend, 8 maps, and descriptive material forming this soil survey report.

The reliability of any soil survey is related to the density of soil inspection sites. As a general rule there were 3 inspections around the periphery of each quarter section. In total, soil characteristics were recorded for approximately 700 different shared sites. Although most of these inspections occurred during the mapping phase, numerous other sites were examined during the checking, correlation and sampling phases of the survey. In less accessible areas of the Milk River Upland the inspection density is less than the average, but it is higher on the plains where most road allowances are accessible. All map units have at least 1 inspection.

2.5 GENERAL SOILS DISTRIBUTION

Most soils in Warner County belong to the Chernozemic Order (Table 6). Solonetzic soils although present are relatively unimportant in terms of areal extent. They occur in scattered areas in both Verdigris Plain and the Milk River Ridge. The majority of soils belonging to the Regosolic Order occur on the recent alluvium associated with the Milk River. Gleysolic soils generally occur as small isolated depressional areas throughout the county.

Prior reference has been made to the relationship between moisture efficiency, vegetation and surface soil color which is used as a primary separation in the classification system. Warner County soils clearly illustrates this relationship (Fig. 2), ranging from the subarid Brown Soil Zone in the north east to the subhumid Black Soil Zone in the southwestern uplands. Brown and Dark Brown soils dominate (Table 6).

2.6 MAP UNIT DESCRIPTIONS

Each of the map units outlined on the accompanying soil maps will be described on the following pages. These descriptions will include soil and landscape features, as well as their extent and location and main land use. They will be listed in alphabetical order to correspond with their arrangement shown on the map legend.

Included in the Appendix to this report are detailed descriptions and analytical characteristics of the more areally important soils in the county. The selected soils are generally those which individually amount to more than 1% of the total area, and are representative of the soils in the county. Collectively these selected soils amount ot about 80% of the county area.

2.6.1 ANTONIO (ANO) SOILS

General setting and description

Antonio soils are well drained, brown grassland soils which have developed in a fluvial veneer of sandy loam overlying till. A subdued hummocky surface landform is a reflection of a similar surface form of the underlying till.

TABLE 6. Soil distribution at the Great Group level in Warner County.

Great Group	Hectares	% of total
Brown Chernozemic	205,380	45.3
Dark Brown Chernozemic	166,320	36.6
Black Chernozemic	20,230	4.6
Total Chernozemic	391,930	86.5
Brown Solonetzic	5,000	1.1
Dark Brown Solonetzic	3,880	0.8
Black Solonetzic	170	·
Total Solonetzic	9,050	1.9
Gleysolic	4,430	1.1
Regosolic	10,290	2.3
Undifferentiated Areas (RB, H_2O, DL, Towns)	37,060	8.2
Total	453,760	100.0

Occurring in an area southeast of Milk River town, these soils occupy almost 1400 ha, of which about 1200 ha is on Class 3 topography, and 200 ha on Class 4 topography. Native vegetation consists mainly of mixed grasses in which needle and thread grass is very prominant, along with many herbs and low shrubs.

Antonio soils are Orthic Brown Chernozemic soils. They have up to 15 cm of a brown colored surface horizon which is weakly structured and has a sandy loam texture. Brown to dark brown upper subsoil colors usually grade to dark yellowish brown in the lower subsoil. Sandy loam textures and a weak subangular blocky structure further characterizes the subsoil. Depth to the underlying clay loam till, although variable, is usually about 50 to 60 cm. Calcium carbonates are present in the till.

Antonio map units

ANBV1 - In this unit Antonio soils are co-dominant with the Bingville soils. The two soils are very similar except that the Bingville profile has developed entirely in the fluvial material, with underlying till at depths greater than one metre. Usually the Antonio soils occupy the higher landscape positions, while Bingville is in the lower positions (Fig. 17). Included in this map unit are occasional small occurrences of loamy sand material, as well as till which surfaces near the crest of some of the hills. On some steeper knolls a Rego Brown Chernozemic profile may be found.

ANBV1, the only Antonio map unit that occurs, was mapped in two topographic phases:
(a) ANBV1/3 with slopes in the 2 to 5% range
(b) ANBV1/4 with slopes in the 6 to 9% range

Land use

The majority of the Antonio-Bingville areas in Warner County are presently being grazed. This is probably its best use despite a relatively low grazing carrying capacity. The moderately coarse textures with their low water holding capacity are the main reason for this low rating. These textures also represent a severe limitation to cultivated dryland agriculture as they are vulnerable to wind erosion. This has already happened to some extent on ANBV1 units which are cultivated. These soils are rated as fair for irrigation, the main limitation being the textural discontinuity presented by the proximity of the underlying clay loam till. A further limitation is the relatively rough terrain particularly on the second phase with its steeper slopes.

2.6.2 BUNTON (BUT) SOILS

General setting and description

In total these soils have been mapped in about 2700 ha, most of which are in Etzikom Coulee. These soils are well drained grassland soils, developed on medium textured fluvial material deposited as fans or aprons within this and similar spillway valleys (Fig. 18). Bunton soils have been mapped mainly in the Brown Soil Zone but have also been extended into similar valley locations in the Dark Brown Soil Zone.

Although Bunton soils are classified as Orthic Brown and Dark Brown Chernozemic soils, their profile development is usually weak and ill defined (Plate II-A). Thus they are often hard to differentiate from the closely associated Rego Chernozemic soils which are quite prevalent. Bunton soils have a 10 cm thick A horizon which is brown in color.

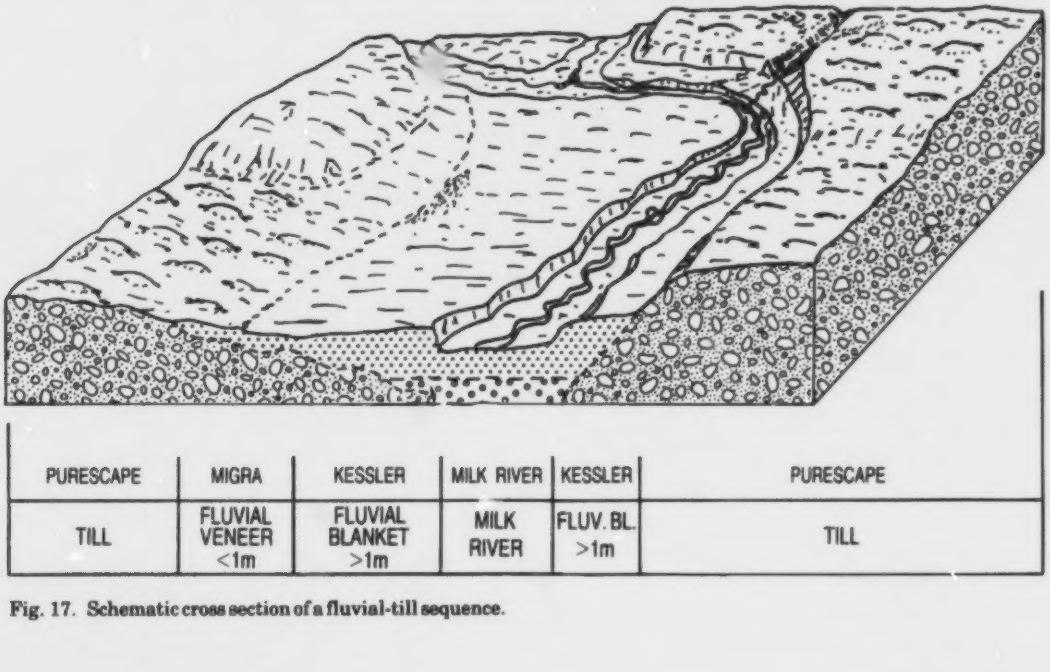


Fig. 17. Schematic cross section of a fluvial-till sequence.

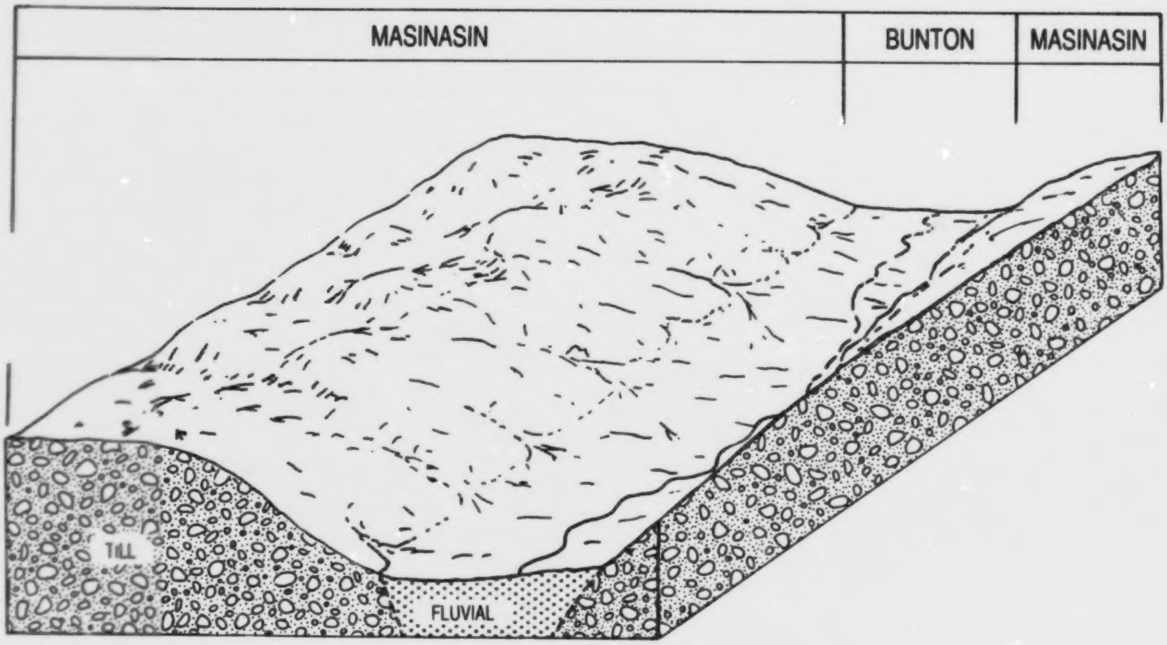


Fig. 18. Schematic cross section of a coulee with Bunton soil in valley.

The brown colors in the upper B horizon gradually change to grayish brown with depth. With this color change there is a corresponding change in structure from weak prismatic to little or no structure. Textures remain fairly constant at loam to clay loam, although in some locations thin sandy to fine gravelly lenses may occur. A lime horizon of low concentration generally occurs near the 60 cm depth in material that tends to be slightly coarser than the upper horizons. Very often these soils are underlain by gravelly sandy loam materials at or below the 1 m depth. A detailed description of a Bunton soil may be found in the Appendix.

Bunton map units

BUT1 - Over half of the Bunton soils in Warner County belong to this unit, the majority of which occur in Etzikom Coulee and Chin Coulee at the north edge of the county. This map unit was also mapped in a shallower coulee extending northward from Long Lake about 15 km west of Coutts. Not only do the Bunton soils in this coulee have a better developed profile than those in Etzikom Coulee, they are also within the Dark Brown Soil Zone.

In the BUT1 unit about 50% of the soils are weakly developed Chernozemic soils. Significant amounts of Humic Regosolic soils occur in close association with the more abundant Chernozemic soils. Both occur on the well drained apron along both sides of the valley. At the lower edges of the apron both saline and gleyed soils may be found. However, they will not exceed 10% of the map unit. Minor occurrences of fluvial gravels (PUN) can be found within this unit. All BUT1 soils were mapped on slopes not exceeding 4%.

BUT3 - About 40% of the Bunton soils belong to this unit, all within Etzikom Coulee. This unit differs from the BUT1 unit in the extent of saline phases which usually comprise about 30% in BUT3. This unit is generally associated with the flatter portions of the coulee, as well as in locations occupied by frequent saline seeps. Dominant soils are similar in kind and extent to those of the BUT1 unit. Similarly this unit has been mapped only on the one topographic phase with slopes less than 4%.

Land use

BUT1 soils are generally marginal for dryland agriculture especially those in the drier Etzikom Coulee. Although they are considered as fair irrigation soils their confined location within coulees may be somewhat limiting. The saline soils in the BUT3 unit are sufficiently limiting to make this unit non irrigable and marginal for dryland farming. For grazing purpose both units have a relatively low carrying capacity.

2.6.3 BINGVILLE (BVL) SOILS

General setting and description

These soils, totalling slightly more than 1000 ha, occur on the east side of the county within Verdigris Plain. They are well drained grassland soils developed on moderately coarse textured fluvial material. Surface landform is variable ranging from undulating to hummocky and ridged.

Bingville soil is classified as an Orthic Brown Chernozemic soil with a brownish colored Ah horizon about 10 cm thick. This Ah horizon grades into a darker brown B horizon which like the Ah, has a sandy loam texture. This texture continues through the pale brown lime horizon, at the 60 to 70 cm depth, and into the paler brown lower horizons. Relatively weak structures persist through the entire profile which grades from neutral pH values in the upper solum to mildly alkaline values in the lower profile.

Bingville map units

BV:G4 - About half of the Bingville soils mapped belong to this unit which is a gravelly phase of Bingville. These soils are concentrated in an area about 11 km north of Writing-on-Stone Provincial Park. The gravel content is variable, but is generally less than 10%. A significant area of the soils, in addition to being gravelly, have an eroded Rego Chernozemic profile and generally occur on the rougher topographic positions. Only one topographic phase of this unit was mapped with slopes ranging from 6 to 9%.

BV:L1 - This unit occurs along the north bank of the Milk River in the vicinity of Writing-on-Stone Provincial Park, where bedrock is relatively shallow. In this unit variable thicknesses of fluvial sandy loams have been deposited directly on the bedrock. Since the majority of the unit has bedrock occurring at less than 1 m, some low ridges of surfacing bedrock are evident. Small amounts of fluvial loamy sands may also occur (Cavendish soils). Near its edges, the unit may include some soils which have developed on a coarse textured till. Slopes ranging from 2 to 5% are general in the one topographic phase that was mapped.

Land use

Coarse textures and limited natural fertility tend to make these two units marginal to unsuitable for annual field crops. For irrigation, the gravelly Bingville has a marginal rating while the unit with underlying bedrock is non irrigable. Both units have a relatively low grazing potential because of the low moisture holding capacity.

2.6.4 BEAZER (BZR) SOILS

General setting and description

Beazer soils are well drained, black grassland soils developed in moderately calcareous, medium textured till materials. They are located in the Milk River Upland (Fig. 19) at elevations generally above 1150 m. The topography ranges from undulating to hummocky and ridged with slopes generally in the 6 to 20% range. The native vegetation is mainly a mixed grass prairie with some fescue and many herbs and shrubs such as lupine and buckbrush in the moister depressional and lower slope positions. The frost-free period is often less than 90 days so these soils are placed in climate zone 2H for agriculture. More than 13000 ha of Beazer soils were mapped in Warner County.

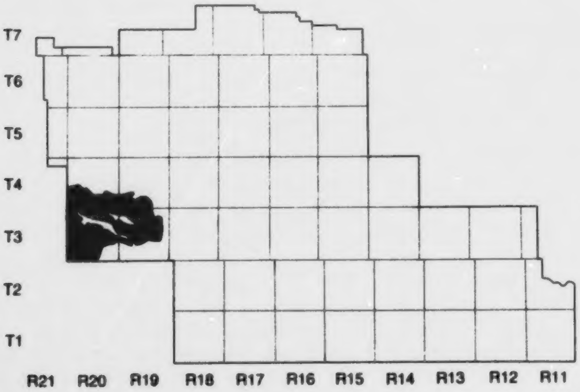


Fig. 19. Distribution of Beazer soils.

Beazer soils have dark grayish brown to black, loam textured surface horizons from 10 to 15 cm thick (Plate II-B). The subsoils are dark brown to yellowish brown, clay loam with good prismatic structure. The calcareous loam to clay loam parent material is encountered at depths of 40 to 60 cms. Stone content is about 5 to 10% with only a few surface stones. These soils have good permeability and water holding characteristics. A detailed description of a Beazer soil is included in the Appendix.

Beazer map units

BZR1 - These units are composed dominantly of Beazer soils with generally less than 20% inclusions of other kinds of soils. On relatively level landscapes the soils are quite uniform but on hummocky or ridged landforms it is common to have thinner soils on the exposed crests and south facing slopes and thicker ones in the lower slope positions. Some of these thinner soils, particularly near the zonal boundary have a dark brown colored surface horizon (PUR soils) reflecting a more arid moisture regime. In some areas the knolls will be stony or even contain small inclusions of gravelly material (RFD soils). Depressional areas will have imperfectly to poorly drained soils and will often contain water for some part of the year.

BZR1 units account for about one third of the area of Beazer soils and were mapped in three topographic phases:

(a) BZR1/4 with slopes in the 5 to 10% range; covers about 900 ha.

(b) BZR1/5 with 10 to 15% slopes; covers about 750 ha.

(c) BZR1/5D-6D with 10 to 25% slopes and many dissections; covers about 400 ha.

The latter units are particularly well drained with few if any undrained depressions. They also tend to have more of the thinner variants associated with the steep slopes.

BZR2 - These units were mapped in hummocky landscapes which have a significant (15 to 25%) amount of undrained depressions many of which contain water for much of the year (Plate I-F). Inclusions of thinner soils some of which may be dark brown in color (PUR) and stony or gravelly soils (RFD) may be encountered on knolls throughout the area. BZR2 units account for 40% of Beazer soils.

Two topographic phases of BZR2 units were mapped:

(a) BZR2/4 with slopes in the 5 to 10% range; covers about 1600 ha.

(b) BZR2/5 with 10 to 15% slopes; covers about 3600 ha.

BZR4 - This unit was mapped in hilly, dissected areas of strong relief and steep slopes primarily along the escarpment at the north edge of the ridge. Beazer soils are dominant but there is a significant component of thin soils on the steep upper slopes. Although this unit occurs on a bedrock controlled landform, shales or sandstones are generally at depths greater than 5 m. These bedrock materials may be exposed in the deeper dissections. There is no standing water in this unit. Only one topographic phase was mapped, BZR4/6D with many slopes in the 15 to 30% range. It amounts to about 1200 ha.

BZRF1 - These units were mapped in strongly hummocky and ridged areas where there are significant amounts (15 to 30%) of soils formed from gravelly ice-contact or washed materials (RFD). The depth of this material is generally less than 3 m and is usually confined to tops or sides of knolls (Fig. 20). A stony surface is a common feature in these areas. Occasional kames (hills of sand, gravel and till) are included. Minor amounts of shallow soils and depressional areas are also included.

Three topographic phases were recognized totalling about 20% of the Beazer soils

(a) BZRF1/5 with slopes of 10 to 15%, covers about 300 ha.
(b) BZRF1/5D with dissected, well drained landscapes and slopes of 10 to 15%; covers about 2700 ha.
(c) BZRF1/6 with many slopes in the 15 to 20% range and several prominant kame-like hills; covers about 200 ha.

BZRF2 - This unit was mapped on hummocky terrain in association with BZRF1. It differs from the latter by having in addition to the Beazer and Rockford soils, a significant component of undrained depressions and sloughs. Only one topographic phase was mapped: BZRF2/5 with most slopes in the 10 to 15% range and covering about 2100 ha.

BZSO2 - This unit was restricted to gently rolling or somewhat hummocky areas within valley situations. Beazer soils dominate but there is a significant amount of stone-free, clay loam lacustrine materials (SOF) particularly in the lower landscape positions. Also, there is 15 to 25% enclosed depressions with poorly drained soils or standing water. Only one topographic phase was mapped: BZSO2/4 with slopes in the 5 to 10% range covering about 400 ha.

Land use

The Beazer soils have good moisture characteristics and good natural fertility. Located in the Milk River Upland the climate is marginal for wheat but good for other cereals and grasses. Both rough topography and stoniness in the BZRF units are limitations to cultivation and dictate the present land use which is mainly grazing. Units with slopes of less than 10% are rated as class 3 for dryland agriculture and those with 10-15% slopes (the /5 units) are marginal at class 4. All units with steep slopes and deep dissections as well as those which are very stony, are unsuitable for cultivated agriculture, but are highly suited for grazing.

2.6.5 CRANFORD (CFD) SOILS

General setting and description

Cranford soils are found extensively within Verdigris and Chin plains (Fig. 21) where they total 14000 ha. They are well drained soils which have developed on a stone-free veneer of lacustrine material overlying till (Fig. 22). Landform characteristics are those of a gently undulating to undulating plain with slopes seldom exceeding 5%.

Cranford is classified as an Orthic Brown Chernozemic soil. Loam to silt loam textures and brown colors prevail in the A horizon which has an average thickness of about 10 cm. Darker colors in the B horizon grade to yellowish brown in the subsoil. Textures below the A horizon are generally silt loam or finer. Lime accumulation usually occurs at about 40 cm below the surface, with till being encountered at 40 to 80 cm (Plate II-C). Neutral pH values at the surface increase to mildly alkaline in the lime horizon and below. A detailed description of a Cranford soil is included in the Appendix.

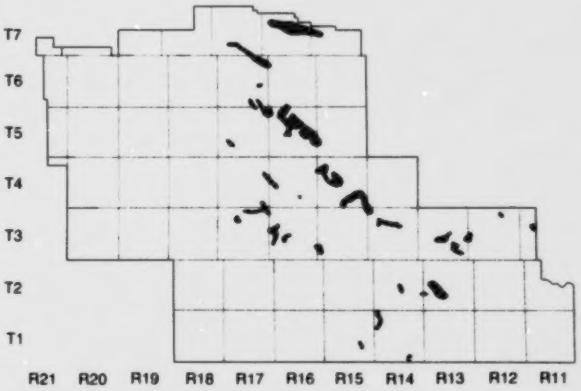


Fig. 21. Distribution of Cranford soils.

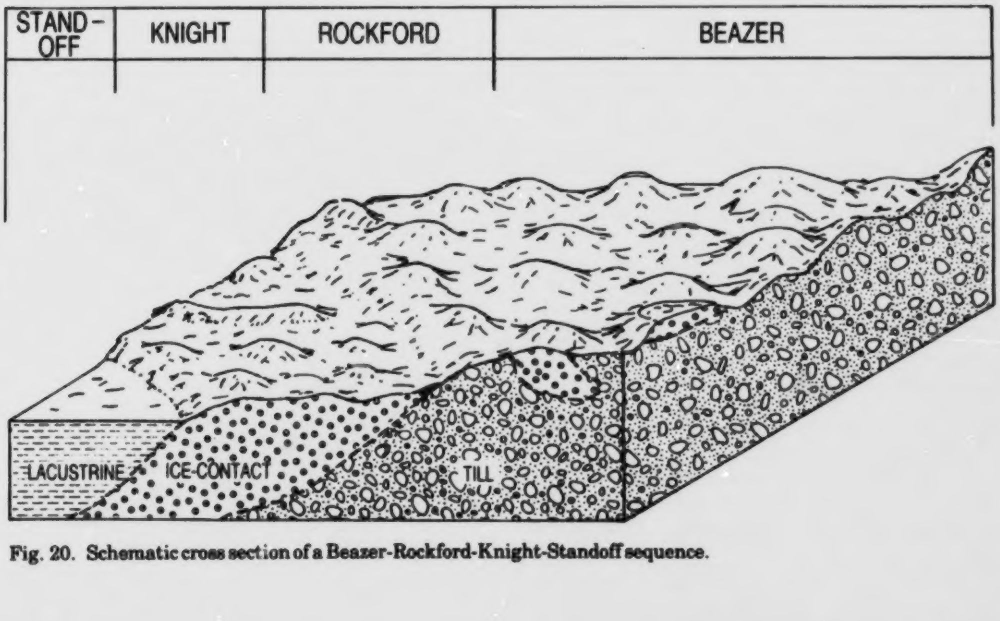


Fig. 20. Schematic cross section of a Beazer-Rockford-Knight-Standoff sequence.

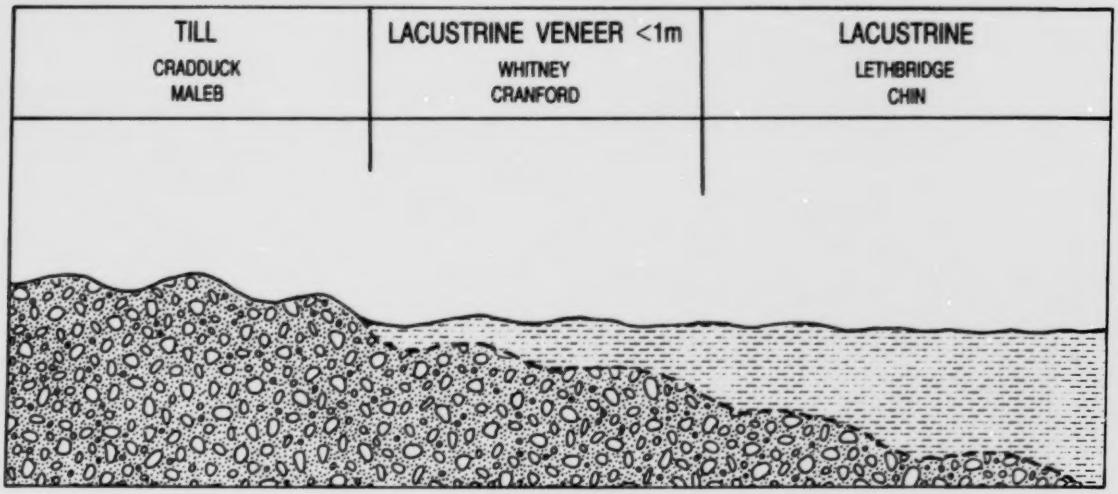


Fig. 22. Schematic cross section of a lacustrine-till sequence.

Cranford map units

CFD1 - More than two-thirds (9000 ha) of the Cranford soils belong to this unit. Although it occurs in both Verdigris and Chin plains it is more prevalent in Chin Plain towards the northeastern part of the county. The unit is composed dominantly of the Cranford soil, but may have up to 30% Chin soil which occurs in locations where underlying till is at depths greater than 1 m, and associated topography is smoother. Rougher portions of the unit, where slopes approach 3%, may have till at the surface resulting in included soils developed on till (MAB or MSN). All CFD1 units occur on slopes ranging from 1 to 3%.

CFD2 - This unit, which in areal extent is slightly more than 2000 ha, can be recognized by the many low areas in which gleyed or Gleysolic soils or sloughs occur. Upland portions of the unit are similar to the relatively pure CFD1 unit, having dominantly Cranford soils. Slopes range from 1 to 4% within this unit.

CFD3 - This unit is characterized by a 20 to 30% occurrence of the saline phase of the Chernozemic profile (LLD). Otherwise it is similar to the CFD1 unit being dominantly composed of Cranford soils. Small amounts of other Chernozemic soils (CHN, MSN) may occur in the unit. Slopes ranging from 1 to 3% further characterizes this unit. About 1500 ha of the CFD3 unit were mapped.

CFBV2 - This unit occupies only about 300 ha in Warner County. It occurs near the east side of the county in a valley between two rather prominent till ridges. This valley has been filled with a veneer or blanket of mixed fluvial lacustrine or fluvial sandy loams, thus resulting in a complex map unit of Cranford and Bingville soils in a 2:1 proportion. Because of its valley location the unit also has a significant amount of gleyed or Gleysolic soils. Slopes within the unit range from 2 to 5% with the steeper slopes occurring near the edges where some till profiles may also be found.

CFCH7 - A little more than 500 ha of this unit occurs near the east side of the county. It can be recognized by the occurrence of soils with Solonetzic characteristics (GEM, DHS, TIK) which total from 20 to 40% of the map unit. The major portion of the unit has Orthic Chernozemic soils developed on a veneer (CFD) or blanket (CHN) of lacustrine material overlying till. These two soils generally occur in equal amounts. Only one topographic phase was encountered with slopes in the 1 to 4% range.

CFMS3 - Slightly less than 500 ha of this unit were mapped in an area about 3 km northeast of Warner. This unit is characterized by a 20 to 30% occurrence of the saline phases of the two codominant soils Cranford and Masinasin. Generally Cranford soils can be found on the lower landscape positions while Masinasin (a till soil) will occur on the higher positions.

A unit with similar soils can be found just south of Warner, totalling about 300 ha. Although it is similar in both kinds and amounts of soils, the one important difference is that underlying bedrock is at less than 5 m. Both this unit CFMS3/3:R, and the unit with the greater depth to bedrock occur on slopes in the 2 to 5% range.

Land use

Almost all Cranford soil areas are being cultivated, primarily for grain production. For dryland agriculture low rainfall is the main limiting factor. However salinity in the CFD3 and CFMS3 units is sufficiently limiting so that these units are marginal and require careful management. For irrigation, only one unit (CFD1) has a high irrigation potential. The two units with significant wet areas (CFD2, CFBV2) are much less desirable for irrigation. Similarly the CFCH7 unit has a low irrigation potential because of the Solonetzic soils. All the units with significant salinity are considered to be non irrigable. All Cranford units have a relatively low grazing capacity, primarily because of the low rainfall.

2.6.6 CHIN (CHN) SOILS

General setting and description

These soils occur on both Chin and Verdigris plains where (Fig. 23) they occupy about 3000 ha. They have developed on stone-free lacustrine material of medium to moderately fine texture. Level to gently undulating landscape features are generally associated with these well drained soils.

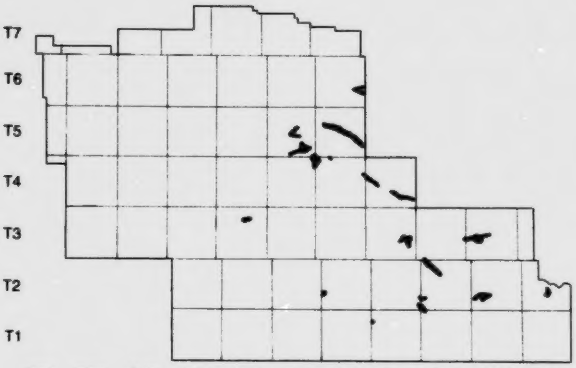


Fig. 23. Distribution of Chin soils.

Chin, classified as an Orthic Brown Chernozemic soil, has up to 15 cm thick A horizon which is brown in color and has a loam to silt loam texture. This horizon grades into a brighter brown and finer textured Bm horizon, which is further characterized by its prismatic structure. Below this, at about the 40 centimetre depth, a $CaCO_3$ horizon occurs. Silt loam textures are usual for these lower subsoils. Close to neutral pH values occur in the upper part of the profile, yielding to mildly alkaline conditions in the subsoils.

Chin map units

CHN2 - More than half of the Chin soil areas belong to this unit which occurs mainly in elongated areas of slightly lower elevation. In addition, about 10 to 30% of the unit is comprised of gleyed and Gleysolic soils and a few small sloughs. Often this unit is underlain by fluvial sands well below the 1 m depth. Occasionally finer textured soils (SPS) or saline phases (LLD) can be found within this unit. Only one topographic phase was encountered with slopes generally being 2% or less.

CHN5 - Only a few isolated areas of this unit were mapped totalling less than 400 ha. In addition to the Chin soil, this unit is recognized by the finer textured soils (SPS) which comprise from 20 to 40% of the unit. Small and insignificant amounts have shallower depths to underlying till (CFD) and wet areas may also occur. This unit occurs on one topographic phase only with slopes less than 2%.

CHBV1 - This unit which occurs on about 900 ha is generally found bordering major drainage ways where soils are often coarser textured due to a fluvial influence. Thus about 20 to 30% of the unit is Bingville, a coarser textured soil than Chin. Also occurring in the unit are a few small areas of sandy loam overlying finer textured material (RIR). One important feature of the CHBV1 unit is that it was mapped only in areas where underlying bedrock is at less than 5 m. Slopes range from 1 to 4%.

Land use

Chin soil areas are generally all being cultivated, primarily for grain production under dryland conditions, even though low precipitation is a limiting factor. The wet areas in the CHN2 unit present an additional obstacle to cultivation, whether that be for dryland or irrigation purposes. The CHN5 unit has a high irrigation potential, but the CHBV1 unit has a lower irrigation rating because of the proximity of underyling bedrock. All three Chin map units have a relatively low grazing capacity because of the low precipitation.

2.6.7 COALDALE (CLD) SOILS

General setting and description

Coaldale soils are concentrated in the northwestern part of the county (Fig. 24) where they total almost 7000 ha. They are the major soils in the lacustrine basin which stretches westward from Stirling towards Welling and Magrath in the adjoining Municipal District of Cardston. An associated level to gently undulating landform (Fig. 25) is typical of the fine textured lacustrine materials on which these soils have developed. Soil investigations indicate that much of this lacustrine area is underlain by sand or gravel at depths usually exceeding 2 to 3 m.

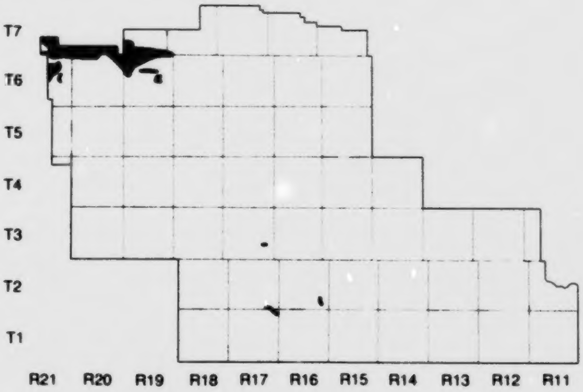


Fig. 24. Distribution of Coaldale soils.

Fig. 25. Level landscapes associated with lacustrine soils. (a CLD area)

Classified as an Orthic Dark Brown Chernozemic soil, Coaldale has a solum with dark brown colors and silty clay loam to clay loam textures. The A horizon, up to 15 cm thick, gradually merges into the B horizon which usually is finer textured and has a prismatic structure. At about the 50 cm depth a moderately to strongly calcareous lime horizon is encountered. Mildly alkaline conditions in the upper profile increase to moderately alkaline in the C horizon. A detailed description of a Coaldale soil can be found in the Appendix.

Coaldale map units

CLD1 - This relatively pure unit has from 60 to 80% of the Coaldale soil. Other soils may occur such as Lethbridge where coarser textures occur, and Whitney in the few locations where underlying till occurs within the 1 m depth. Up to 20% of the soils in this unit may be salinized. About 35%, or 2400 ha of the Coaldale soils belong to this unit. Only one topographic phase was mapped on slopes not exceeding 3%.

CLD3 - About 800 ha were mapped as CLD3 primarily in the area around Stirling. From 20 to 40% of the soils in this unit have been salinized, probably from irrigation water as they are located in irrigated areas. These salinized units generally occur in lower areas along drainage ways. Under a few of these units bedrock may occur at depths of less than 5 m. This unit occurs only on one topographic phase with slopes of less than 4%.

CLLE1 - More than half of the total Coaldale soil area belongs to this unit. Most occurs in the southern portion of the lacustrine basin between the CLD1 areas in the central portion of the basin and till areas bordering the basin to the south. Although the unit is dominated by Coaldale soils there is a 30 to 40% content of the siltier Lethbridge soil. There may also be inclusions of soils that have till at shallow depths (WNY). It was found that about 1/3 of this unit has bedrock within 5 m of the surface. Only one topographic phase, with slopes of less than 2%, was recognized.

Land use

As they lie within the Raymond Irrigation District a large proportion of the Coaldale soils are being irrigated. Since this area has less than 2100 Corn Heat Units, climate somewhat restricts the crops that can be grown on these soils. Salinity in the CLD3 unit renders this unit unsuitable for irrigation, as well as reducing its rating for dryland agriculture and grazing. Both the CLD1 and CLLE1 units have similar high ratings for dryland agriculture as well as grazing.

2.6.8 CLARINDA (CLR) SOILS

General setting and description

Almost 700 ha of Clarinda were mapped, all within Verdigris Plain. This morainal soil, associated with steep slopes, occurs on some of the rough land along Verdigris Coulee, as well as on some isolated ridges within areas of ground moraine.

Clarinda is classified as a Rego Brown Chernozemic soil. The A horizon is usually thin but may sometimes reach a thickness of 15 cm. It is weakly calcareous and has a weak granular structure. Directly below, the C horizon is moderately to strongly calcareous. Loam to clay loam textures are fairly consistent throughout the profile. The pH values generally increase from mildly alkaline in the upper profile to moderately alkaline in the subsoil.

Clarinda map units

CLR1 - Soil components in this unit are dominantly the Clarinda soil with a 20 to 30% content of the Orthic profile (MSN). On areas where slopes are excessively steep one can expect to find an Orthic Regosol profile, which may amount to about 15% of the unit. One topographic phase was recognized with slopes in the 10 to 15% range.

Land use

More than half of the unit is being cultivated resulting in accelerated water erosion. To reduce this, Clarinda soil areas should be in forage crops or permanent pasture, even though the carrying capacity is low. Due to the associated steep slopes this unit is non irrigable.

2.6.9 CRADDUCK (CRD) SOILS

General setting and description

Cradduck soils are one of the more important in terms of extent, occupying about 78,000 ha or more than 17% of the total county area. They are the principal soils in the Dark Brown Zone (fig. 26).

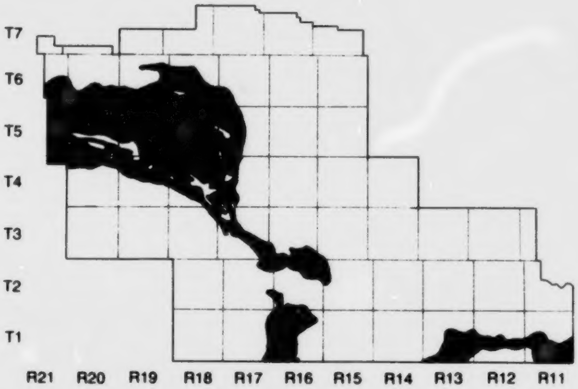


Fig. 26. Distribution of Cradduck soils.

They are well drained soils developed on moderately calcareous loam to clay loam till with a relatively high silt content. Landscape features are those of various morainal landform ranging from the gentle slopes of ground moraine (Plate I-E) to the steeper slopes of hummocky moraines. Cradduck soils which occur closer to the Milk River Upland or the Sweetgrass Upland often have an associated steeper topography which can be both inclined and dissected. About 25% of the Cradduck soil areas have bedrock at less than 5 m below the surface. Associated native vegetation is that characteristic of the transition zone between Fescue Grassland and the Mixed Prairie association.

Cradduck is classified as an Orthic Dark Brown Chernozemic soil. Dark brown colors in the upper profile overlie grayish brown colors in the subsoil. Silt loam to silty clay loam textures prevail in materials which are friable and weakly structured. A moderately calcareous lime horizon occurs near the 30 to 35 cm depth. Neutral to mildly alkaline pH values in the upper profile generally increase to moderately alkaline in the subsoil. Cradduck soils have about a 2% content of coarse fragments. A detailed description of a Cradduck soil can be found in the Appendix.

Cradduck map units

CRD1 - These relatively pure units are composed dominantly of the Cradduck soils. When they occur on landscapes with steeper slopes such as hummocky or dissected landforms they often have up to 20% inclusions of the Rego Dark Brown Chernozemic soil (VEB). More than 20% have underlying bedrock occurring less than 5 m below the surface. These units account for almost half of the total areal extent of Cradduck soils.

Four topographic phases were mapped:

(a) CRD1/2 with slopes of 1 to 2%; covers about 2100 ha, 25% is shallow to bedrock.
(b) CRD1/3 with slopes of 2 to 5%; covers more than 25,000 ha, 25% is shallow to bedrock.
(c) CRD1/4 with slopes from 6 to 9%; covers more than 8500 ha, about 15% is shallow to bedrock.
(d) CRD1/4D with slopes from 6 to 9% and many dissections; covers about 2100 ha.

CRD2 - The distinguishing feature of this unit is the significant amount of low and poorly drained areas in which water or Gleysolic soils occur. Cradduck soils which are dominant, occupy the upland portions of the unit where the Rego Dark Brown Chernozemic soil (VEB) may also occur, especially where steeper slopes are present. The main occurrence of this minor unit (3% of CRD soils) is in an area on the north side of Milk River Ridge Reservoir.

This unit was mapped on one topographic phase only (CRD2/3-4) with slopes ranging from 3 to 8%. About 2400 ha are present of which only a minor portion has underlying bedrock within 5 m of the surface.

CRD3 - This unit can be recognized by the presence of salinity which has effected 20 to 40% of the unit. Salinity is present primarily as the salinized phase of Cradduck, but may also occur as small saline spots which are more severely salinized. The majority of the unit, which is non-saline, is characterized by the Cradduck soil. Inclusions of the Rego Dark Brown Chernozemic soil (VEB) as well as gleyed and Gleysolic soils may occur. Less than 1% of the Cradduck soils belong to this unit, mapped as small isolated areas north of the Milk River Upland.

Only one topographic phase was recognized (CRD3/3) with slopes of 2-5%. Of the approximately 700 ha mapped, well over half had bedrock at less than 5 m below the surface.

CRD4 - These are units in which 20 to 50% of the soils are Rego Dark Brown Chernozemic (VEB) (Fig. 27). Although the amount of Cradduck is less than in other Cradduck units, it is still dominant. Units on steeper slopes will also have inclusions of Orthic Regosols. Where units are characterized by hummocky topography, sloughs and Gleysolic soils may occur.

Fig. 27. A CRD4 map unit. Note the eroded knolls.

Most of these units can be found associated with the lower slopes leading away from the Milk River Ridge, as well as similar landforms adjacent to the Sweetgrass Upland. Minor occurrences of CRD4 have also been mapped on some ridged and other rough topography adjacent to spillways and drainage channels. A little more than 12,000 ha were mapped, a significant proportion of which had underlying bedrock within 5 m of the surface.

Four topographic phases were mapped:

(a) CRD4/4 with slopes in the 6 to 9% range; covers about 8200 ha, of which more than 50% is shallow to bedrock.
(b) CRD4/4D with slopes from 6 to 9% and numerous dissections; covers about 1700 ha, 1/4 of which is shallow to bedrock.
(d) CRD4/5D with slopes from 10 to 15% and numerous dissections; covers about 900 ha of which about 10% has bedrock within 5 m of the surface.

CRD6 - These units have a 20 to 40% content of coarse textured soils which occur as small isolated areas, too small to outline, within a dominantly Cradduck soil area. A variety of coarse textured fluvial soils may occur which individually will not exceed 20% of the unit. The most frequently occurring are the sandy loams of variable depth (KSR or MGR), as well as some gravelly soils. CRD6 units occur in widely separated locations. They comprise about 2% of all Cradduck soils.

Two topographic phases were mapped:

(a) CRD6/3 with slopes from 2 to 5%; covers about 1100 ha.
(b) CRD6/5 with slopes from 10 to 15%; covers about 200 ha.

CRD7 - This unit is characterized by the presence of Solonetzic soils which total from 30 to 50% of the unit. These Solonetzic soils are too small to outline within an area of dominantly Cradduck soil. Almost equal amounts of Dark Brown Solod and Solodized Solonetz can be found as well as the Solonetzic Dark Brown Chernozemic soil. Eroded pits are a common feature, particularly along dissections. One can expect saline subsoils to be associated with this unit.

Less than 1% of the Cradduck soils belong to this unit, more than half of which occur on the inclined and dissected topography adjacent to the Sweetgrass Upland. The remainder occurs as isolated areas elsewhere in the western part of the county.

Only one topographic phase was mapped with slopes ranging from 6 to 9% and many dissections. Of the 600 ha mapped approximately half has bedrock within 5 m of the surface.

CR:P1 - This unit can be recognized by its stony surface which has stones varying from boulders to gravel sizes. The stony phase of Cradduck makes up more than 60% of the unit. The remainder contains non-stony Dark Brown Chernozemic soils such as Cradduck or Verburg, which individually do not exceed 20%. Occasionally the unit has some poorly drained areas with either water or Gleysolic soils. Less than 1% of the Cradduck soils belong to this unit which occurs along portions of some drainage channels west of Tyrell Lake.

One topographic phase was mapped with slopes from 3 to 8%. The unit totals nearly 500 ha all of which has underlying bedrock at less than 1 m.

CRNE1 - Dark Brown Chernozemic soils on two different deposits characterize this complex unit. About 60% has developed on till (CRD) and up to 30% on fluvial outwash (NED). Up to 20% of the unit may have various stony phases. Generally the New Dayton soil occurs on ill-defined ridges and slightly higher topographic positions.

Less than 1% of all Cradduck soils belong to this unit. It occurs in two equal sized areas; one near the east end of Kipp Coulee, the other along the south side of Milk River Reservoir.

One topographic phase was recognized with 2 to 5% slopes. The 250 ha mapped had underlying bedrock within 5 m of the surface.

CRNE3 - Except for the salinity, this unit is in every respect similar to the CRNE1 unit. Saline phases amount to about 20 to 30% of the unit. In total it accounts for 1% of all Cradduck soils. The bulk of this unit is located around the village of New Dayton. Another area does occur along Kipp Coulee about 8 km west of New Dayton.

The one topographic phase recognized has slopes in the 2 to 5% range. This unit totals 800 ha, all of which has bedrock within 5 m of the surface.

CRWN1 - In these units Cradduck is still dominant but significant portions have a moderately fine textured veneer of lacustrine material overlying till (Fig. 22). In these locations, which amount to 20 to 50%, an Orthic Dark Brown Chernozemic profile (WNY) has developed. These lacustrine deposits generally occur in the lower and slightly smoother landscape positions. These units may also include small amounts of Chernozemic soils on deeper lacustrine (LET) as well as Rego profiles on till (VEB). Some units may also have minor inclusions of poorly drained areas.

About 25% of all Cradduck soils have been mapped as CRWN1. Although some smaller areas do exist, the majority occur as large tracts that are several sections in size. Their occurrence is most prevalent in the general area from Tyrrell Lake to the western county boundary. The majority of these units occur on relatively smooth topography, except for locations traversed by slight drains resulting in steeper slopes.

Two topographic phases were recognized;

(a) CRWN1/3-2 with slopes from 1 to 4%; covers about 15,000 ha of which 20% has bedrock within 5 m.

(b) CRWN1/4 with slopes from 6 to 9%; covers about 750 ha.

CRWN2 - The soil component of this unit has equal amounts (30 to 50%) of the two dominant soils Cradduck and Whitney. Its main difference from the CRWN1 unit is the 15 to 30% content of poorly drained areas of gleyed and Gleysolic soils in undrained depressions. This unit occupying less than 1% of the Cradduck soil areas occurs as isolated areas associated with the main CRWN1 units.

One topographic phase was mapped on slopes in the 2 to 5% range, totalling about 400 ha.

CRWN6 - This unit also has equal amounts (40 to 60%) of Cradduck and Whitney soils. However it differs from previously described units because it has a 10 to 30% content of coarser textured and sometimes gravelly soils of fluvial origin. Its occurrence is limited to an area a few kilometres south of Milk River Ridge Reservoir where it occurs along one of the deep dissections in that area. It is relatively insignificant as it makes up less than 1% of the Cradduck soils.

One topographic phase was mapped with slopes in the 2 to 5% range totalling about 250 ha.

CRWN7 - This unit is distinguished by the presence of Dark Brown Solod and Solodized Solonetz soils which total from 20 to 40%. The unit also contains a similar amount of Whitney along with the 40 to 60% content of Cradduck. Minor amounts of both the Solonetzic and Rego Dark Brown Chernozemic soils may be present. This unit also represents less than 1% of the Cradduck soils. It occurs on two general areas; one below the Milk River Upland southeast of the Milk River Ridge Reservoir, the second near the International border east of the Sweetgrass Upland.

One topographic phase was recognized with slopes of 2 to 5%, and it has an areal extent of almost 700 ha.

Land Use

Most Cradduck soil areas are being cultivated mainly under dryland conditions. A few areas are irrigated in the Raymond Irrigation District. The little that is being grazed is mainly where topography is too rough for arable agriculture.

More than 75% of the Cradduck soil areas have no major limitation to agricultural production other than the relatively low precipitation characteristic of the area. Water erosion, however, is a constant threat because of the high silt content of these soils. About 8% occurs on topography rough enough to render such areas marginal or unsuitable for dryland agriculture, and non irrigable. Approximately 3% is non irrigable because of the presence of low wet areas ("2" units). Salinity occurs on about 2% resulting in such areas being non irrigable and marginal for dryland agriculture. This salinity is also a limitation to the grazing potential. A fairly large percentage (10%) has significant Rego Chernozemic soils in the unit. These soils usually have lime at the surface in sufficient concentrations to adversely affect plant growth, consequently these units ("4" units) are poor or marginal for dryland agriculture. The units which have a significant amount of Solonetzic soils ("7" units) are also less desirable for dryland agriculture, and their grazing potential is also lowered. These soils which amount to only 1% of the Cradduck soils are considered to be nonirrigable. The stones in the CR:P1 unit are numerous enough to make this unit nonarable. Coarse textured components in the CRNE units lower its rating for both dryland and irrigated agriculture as well as its grazing potential.

2.6.10 CAVENDISH (CVD) SOILS

General setting and description

Cavendish soils have developed on sandy fluvial or eolian material. Landscape features are those of an undulating plain with some ridged characteristics. These rapidly drained soils occur mainly in the southern part of the county associated with the Milk River and some of its tributaries. They are one of the less common soils, in total occupying less than 1% of the county area.

Cavendish is classified as an Orthic Brown Chernozemic soil. It has a brownish colored solum developed in a structureless and loose loamy sand to sand. The gradual change from one horizon to another is mainly in color, which grades from a grayish brown surface color, through a brown B horizon, and into a pale brown C horizon. Usually pH values increase with depth from slightly acid to neutral in the surface horizon, to neutral in the B horizon, and neutral to mildly alkaline in the C horizon. If a $CaCo_3$ horizon is present it is usually near the one metre depth or below.

Cavendish map units

CVD1 - This is the only unit mapped and is composed almost entirely of Orthic Brown Chernozemic soils, of which

Cavendish is dominant. From 10 to 30% of the unit has underlying till within 1 m (PLS soil). An equal portion of the unit has sandy loam textures (BVL soil). There may also be inclusions of till (MSN soil) or the Rego Brown Chernozemic soil (VST) also with loamy sand to sand textures.

One topographic phase was recognized with slopes in the 2 to 5% range, covering about 400 ha.

Land use

Cavendish soils are nonarable under dryland conditions because of their low water holding capacity and susceptability to wind erosion. Therefore they are best suited for grazing even though they have a low carrying capacity. This soil has a fair rating for irrigation.

2.6.11 DISHPAN (DHP) SOILS

General setting and description

The total extent of these soils is a little more than 1000 ha. They occur in widely separated areas mainly in the Verdigris Plain, with lesser amounts in the Chin Plain. Dishpan soils are poorly drained, and occur primarily in drainage channels in which medium to moderately fine lacustrine or fluvial lacustrine materials have been deposited. These soils are very saline resulting in a patchy vegetative cover. Locations of more severe salinity are often devoid of vegetation while salt tolerant grasses and herbs are found elsewhere.

Dishpan soils can be recognized by their strongly saline condition which results in salts being visible on the surface and in the exposed profile whenever drying takes place. Classified as a Rego Gleysol, saline phase, this soil has no profile development except for a thin to absent Ah horizon. Upper profile textures of silt loam usually become finer with depth. Olive gray colors and a massive structure as well as a medium lime content are common features of the C horizon.

Dishpan map units

DHP1 - About 70% or more of the Dishpan unit is composed of the saline phase of this Rego Gleysol soil. The remainder of the unit is comprised of the saline phase of the Orthic Chernozemic soil (LLD) and other Gleysolic soils. It is not unusual to find small water bodies associated with this unit. Of the total 1000 ha of Dishpan soils, about 20% ha has bedrock at less than 5 m - the DHP1/2: R unit. Regardless of depth to bedrock all Dishpan units have a very gently undulating topography.

Land Use

In Dishpan areas the saline conditions are so limiting that these soils are both non irrigable and non arable. Thus their only agricultural use is grazing which is low, even in the best portions of the unit.

2.6.12 DISTURBED LAND (DL)

About 1000 ha are included in this map unit. It includes areas which have been removed from agricultural production due to land disturbance within townsites as well as excavation areas for gravel or fill material. The majority of the areas included in this unit are townsites while only 10% are gravel pits.

2.6.13 FORK (FOR) SOILS

General setting and description

These well drained soils have developed on a veneer of moderately coarse textured fluvial material overlying lacustrine deposits. Their occurrence is confined to the extensive fluvial deposits within the broad valley of the Milk River Plain west of Highway 4. Associated landform features are generally those of an undulating plain with a few low ridges.

Fork is an Orthic Dark Brown Chernozemic soil. It has a granular structured, sandy loam A horizon, and usually has a similar or finer texture in the B horizon. The underlying material usually has a silt loam or finer texture and is quite mellow. Considerable variability can occur in the thickness of overlay, varying from 25 centimetres to nearly one metre. Profile colors, grayish brown at the surface, change to yellowish brown in the subsoil. Near neutral to mildly alkaline pH values prevail above the moderatly alkaline lime horizon.

Fork map units

FOKS1 - In Warner County Fork soils were always found associated with deeper fluvial deposits (KSR soils). In a few locations, no fluvial veneer exists resulting in a Chernozemic profile developing in finer lacustrine material (LET soil). This latter soil however never exceeds 10% of the unit. Low wet areas of gleyed or Gleysolic soils sometimes occur. Total extent of this unit is about 900 ha.

One topographic phase was mapped with slopes of 2 to 5%.

Land use

The main limitation of the FOKS1 unit to dryland agriculture or grazing is its less than adequate moisture holding capacity. For irrigation the textural difference between the fluvial veneer and underlying lacustrine material has the potential for lateral water movement and subsequent seepage problems.

2.6.14 GLEYSOLIC (G) SOILS

This unit includes the numerous small poorly drained areas (sloughs or potholes) in which Gleysolic soils occur. They have been so named because it was impractical during the course of the soil survey to visit each one and further classify the soils. Although they are numerous, their total area of 1120 ha is considerably less than 1% of the total county area. They occur throughout the county (Fig. 28) as isolated depressions many of which contain water well into the summer months.

Land use

When these areas occur in cultivated areas they become a nuisance because they are usually too wet to cultivate. However when they occur in areas where grazing is the dominant land use, such as in the Milk River Upland they are an asset, as they may have a higher carrying capacity than the surrounding land.

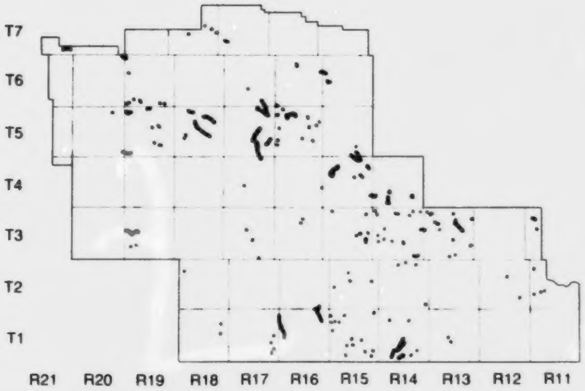


Fig. 28. Distribution of Gleysolic soils.

2.6.15 GEM (GEM) SOILS

General setting and description

This is a moderately well drained soil. It has developed on a veneer of medium to moderately fine textured lacustrine material overlying till. Generally it can be found on a level to undulating plain. Gem is classified as a Brown Solod. It has an 8 to 10 cm thick Ah horizon with a loam to silt loam texture. Its brown color grades to a brownish gray Ae horizon which in turn grades to an AB horizon. This latter horizon is darker in color and much finer textured and has a subangular blocky structure. The underlying columnar structured Bnt horizon has a silty clay loam texture and a dark brown color. Lime usually occurs near the 40 cm depth, just above the depth at which till normally is encountered. Slightly acid to neutral pH values prevail in the A horizon increasing to mildly alkaline in the B horizon and moderately alkaline in the lime horizon and below. Sulphate salts are present in the C horizon.

Gem map units

GEM3 - This is the only Gem unit recognized in the county. Gem soil is dominant representing from 40 to 70% of the unit. Other Solonetzic soils present in significant amounts may include Brown Solodized Solonetz (WDW and DHS), and Brown Solod developed on till (HDY). However, the most significant characteristic of the unit is the saline phase of the Orthic Brown Chernozemic soil (LLD). Salinization may also have effected other soils in the unit. Minor amounts of other Solonetzic soils may also occur.

This unit which totals 600 ha was mapped primarily in an area near the International border about 15 km east of Coutts. There it occurs in a basin-like area, which probably receives ground water discharge from the surrounding higher till areas. One topographic phase was recognized with slopes in the 1 to 4% range.

Land use

Although parts of the unit are being cultivated it should be utilized mainly for forage crops or improved pasture. The saline conditions, aggravated by the Solonetzic nature of the soils make the unit unsuitable for both dryland or irrigated crop production. These characteristics are also responsible for a relatively low grazing carrying capacity.

2.6.16 GLEDDIES (GLS) SOILS

General setting and description

This soil is relatively minor in Warner County, occurring only within the unnamed spillway stretching southeast from New Dayton towards the railway siding of McNab. It occupies about 130 ha in the northern part of this spillway. This poorly drained and saline soil has developed on moderately fine to fine textured lacustrine material. Because of the saline nature of the soil, vegetative cover is rather sparse and limited to salt tolerant grasses such as wild barley (foxtail barley).

Gleddies soils are classified as Rego Gleysols, saline phase, as they have no profile development except for a very thin to absent Ah horizon. Dull olive gray colors prevail in a material that has a silty clay loam to silty clay texture and a massive structure. Strongly saline and moderately alkaline conditions are common within and below the 1 m depth. The higher clay content distinguishes this soil from Dishpan soils.

Gleddies map units

GLS1 - This unit, composed almost entirely of the Gleddies soil, is the only one mapped. Very minor amounts of the saline phase of the Orthic Chernozemic soil (LLD) may occur at the edges of the area. A few large stones or boulders, presumably ice-rafted, are embedded in the surface of parts of the unit.

Land use

Gleddies soils, because of their salinity and poorly drained condition, are unsuitable for both dryland and irrigated agriculture. Despite a low carrying capacity, grazing is still its best agricultural use.

2.6.17 GRUDGE (GRG) SOILS

General setting and description

Grudge soils occur only on the Milk River Upland where they total a little more than 1000 ha. They have developed on moderately saline till, possibly derived from the Bearpaw formation which underlies part of the Milk River Upland (Fig. 9). These soils occur on some of the undulating and inclined slopes between the Milk River and the higher morainal uplands of the Milk River Ridge. Under these inclined slopes, bedrock is often at less than 10 m below the surface.

These soils, which are classified as Dark Brown Solodized Solonetz, can be recognized by the columnar round topped structure of the B horizon. The dark brown color of the Ah horizon gradually changes to a dark grayish brown in the Ae horizon which is 1 or 2 cm thick. Loamy textures in the A horizon change abruptly to clay loam or finer in the Bnt horizon at about the 16 cm depth. Because this latter horizon is very compact and resistant to breakdown, root penetration is difficult. A lime horizon is usually encountered near the 35 to 40 cm depth in a clay loam material. Neutral to slightly acid pH values in the A horizon increase to mildly alkaline in the B horizon and moderately alkaline in the Cca horizon. A detailed description of a Grudge soil is included in the Appendix.

Grudge map units

GR:E1 - All of the Grudge soils mapped belong to this unit. A very obvious feature is the eroded character of the soils to the extent that little or no A horizon remains over most of the area. Although most of the soils are the eroded phase of the Solodized Solonetz (GRG) about 30% of the unit consists of the Dark Brown Solod, eroded phase. Another feature is that the inclined slopes associated with the unit are often dissected by shallow drainage channels along which the more severely eroded soils occur.

Although the unit occurs on both sides of the Milk River, it is most prevalent on the south side. Associated slopes are generally in the 2 to 5% range. About 10% of the unit has underlying bedrock within 5 m of the surface.

Land use

Because of their eroded condition and the undesirable structure of the B horizon, Grudge map units are not suitable for crop production. Their present land use, grazing, is the best alternative, despite their low carrying capacity.

2.6.18 HALLIDAY (HDY) SOILS

General setting and description

These soils occur only in that part of Verdigris Plain lying in the south eastern part of the county. They occupy almost 2000 ha generally in the area between the Sweetgrass Upland and the Lucky Strike area, centred in township 3 at the east edge of the county. These two upland areas slope north and south respectively towards the Milk River which separates them. It is on the lower portions of these slopes that the Halliday soils occur. They have developed on a blanket of morainal material up to 10 m thick which overlies bedrock.

Halliday is classified as a Brown Solod. It can be recognized by a remnant transitional AB horizon which often retains the round topped form, but not the strong secondary structure of the former Solodized Solonetz from which it has evolved. The transition to the columnar structured Bnt horizon is gradual, both in color and texture. Clay loam textures and dark brown colors are normal characteristics of the Halliday B horizon. Horizons above are brown to grayish brown. The structural characteristics of the Bnt horizon gradually becomes less obvious through the BC horizon, disappearing entirely in the Cca horizon, at about 40 to 50 cm. Salts are usually present at these lower depths. Mildly alkaline pH values in the B horizon increase to moderately alkaline in the lime horizon. Above, in the A horizon, slightly acid conditions prevail.

Haliday map units

HDHU1 - Only one Halliday map unit was recognized. It consists of nearly equal amounts of Halliday and the Brown Solodized Solonetz (HUK). Eroded pits where the A horizon has been eroded away, are a common feature occurring on 10 to 30% of the unit. Generally the Halliday profile can be found in the non eroded portions, and the Hemaruka profile (HUK), eroded phase, in the pits.

About 60% of this unit occurs on the north side of the Milk River where bedrock is generally less than 5 m below the surface (the:R unit). The remaining 40% south of the river has underlying bedrock occurring from 5 to 10 m below the surface. Both units have slopes in the 3 to 7% range.

Land use

Presently most of these soils are being grazed, probably their best use as they are marginal for arable dryland farming because of their solonetzic structure and the low rainfall. These solonetzic characteristics are also responsible for a poor irrigation rating. The areas with shallower bedrock have an added limitation making them unsuitable for irrigation.

2.6.19 HEGSON (HEG) SOILS

General setting and description

Hegson soils were mapped at the western edge of the county within the Milk River Plain. There, they occur on both sides of the river and total almost 400 ha. They have developed on a fine textured glaciolacustrine material overlying till (sometimes called lacustro-till). There is an overall general slope towards the river.

Hegson is classified as an Orthic Dark Brown Chernozemic soil. The 10 cm thick Ah horizon has a dark grayish brown color, which becomes darker in the B horizon. Silty clay loam textures in the A horizon change to silty clay in the B horizon and below. The profile generally is weakly structured, subangular blocky in the A horizon and prismatic in the B horizon. Lime accumulation generally occurs near the 30 cm depth, although some profiles may be weakly carbonated above the Cca horizon. Both the A and B horizon have neutral pH values, but this changes to moderately alkaline in the lower profile. A few stones are usually present in this soil.

Hegson map units

HEG1 - This unit consists almost entirely of the Hegson soil. Very minor amounts of siltier lacustrine material overlying till (LUP) may occur, as well as the occasional wet area. Slightly more than half of the Hegson soils belong to this unit. Only one topographic phase was mapped with slopes in the 2 to 5% range.

HEG7 - More than half the soils in this unit are Hegson, the remainder being mainly solonetzic in character. Almost equal amounts can be found of the Solodized Solonetz and the Solod. These solonetzic soils occur indiscrimanently within the unit but can usually be identified by the associated "blow-out" pits. This unit occurs only on the south side of the river where associated slopes are in the 1 to 2% range.

Land use

The high clay content and the resulting high moisture holding capacity result in a relatively high rating of Hegson soils for both dryland farming and grazing. However, the solonetzic characteristics of the HEG7 unit lowers its rating. For irrigation the HEG1 unit has a fair rating, but the HEG7 unit is non irrigable. Both units are presently being grazed.

2.6.20 HEARTBREAK (HRK) SOILS

General setting and description

These soils are concentrated in the Milk River Plain (Fig. 29) between the town of Milk River and the western edge of the county. They have formed on very coarse textured fluvial deposits which are most abundant on the

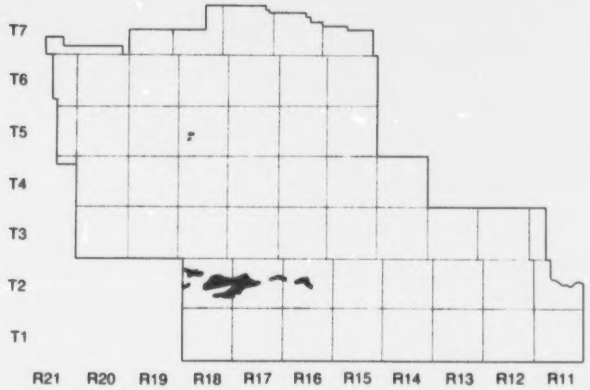


Fig. 29. Distribution of Heartbreak soils.

south side of the river. Associated landforms are generally undulating to hummocky with some ridged tendencies, especially where wind action has redeposited the material. Total extent of Heartbreak soil is 4000 ha.

Heartbreak is classified as an Orthic Dark Brown Chernozemic soil. It has a loamy sand Ah horizon from 10 to 15 cm thick, which has a dark grayish brown color and a loose single grain structure. This structure continues into the darker brown B horizon, which is up to 20 cm thick and also has a loamy sand texture. Colors gradually fade to a pale brown in the C horizon, which is composed of very loose sand. Lime, if present in the lower C, is in very low concentrations. Neutral pH values in the A horizon gradually change to mildly alkaline in the C horizon.

Heartbreak map units

HRK1 - This unit occupies about 35% of the total Heartbreak soil area. The unit has up to 70% of the Heartbreak profile. The remaining soils are also Orthic Dark Brown Chernozemic but are developed on sandy loam textures (KSR, FOR, or MGR). Some Regosolic soils may also occur, especially where steep slopes are present. One small area was mapped which had underlying bedrock at less than 5 m. All HRK1 units have slopes in the 3 to 8% range.

HRK4 - This, the most prevalent of the Heartbreak units, occurs on almost 40% of the total Heartbreak soil area. Soil components are similar to the HRK1 unit except there is about 30% of the Rego Chernozemic profile present. This is associated with an increased amount of wind deposited material where these Rego Chernozemic profiles are concentrated.

Two topographic phases were mapped:

(a) HRK4/4 with slopes of 6 to 9%; covers about 1300 ha of which a very minor amount has bedrock within 5 m of the surface.

(b) HRK4/5 with slopes of 10 to 15%; covers about 300 ha.

HRNE1 - About 25% of the Hearbreak soils belong to this unit. It consists dominantly of Heartbreak and a 30% content of soils developed on gravelly fluvial material (NED). Usually these coarse textured gravelly soils occur on ridges.

Two topographic phases were recognized:

(a) HRNE1/3 with slopes of 2 to 5%; about 450 ha were mapped.

(b) HRNE1/4 with slopes of 6 to 9%; about 600 ha were mapped.

Land use

Heartbreak units are usually poor to marginal for dryland farming. Their sandy nature makes them susceptible to wind erosion especially if they are in grain production. Their coarse textures also result in a low water holding capacity. Thus they are best suited for grazing purposes despite a relatively low carrying capacity. Their irrigation rating is only fair on the better topographic units while those on rougher topography are non irrigable. Some HRNE units may be a possible source of gravel.

2.6.21 HEMARUKA (HUK) SOILS

General setting and description

In terms of extent these soils are relatively unimportant as they occur on less than 150 ha. They have developed on a moderately saline till with undulating to hummocky landform characteristics. Their occurrence is limited to the southern part of Verdigris Plain north of the Sweetgrass Upland.

Hemaruka is classified as a Brown Solodized Solonetz soil. Its main distinguishing feature is the hard columnar round topped structure of the Bnt horizon, which is very resistant to breakdown and to plant root penetration. This horizon has a clay loam to clay texture, a dark grayish brown color, and a neutral to mildly alkaline reaction. The A horizon is divided into an Ah horizon about 8 cm thick, and an Ae horizon about 3 cm thick. Both have a loam texture, and a neutral to slightly acid reaction. The lower B horizon has a weaker structure than the Bnt and gradually increases in alkalinity as it approaches the Cca horizon at about 35 cm below the surface. Lighter colors are also characteristics of these lower horizons as are moderately alkaline pH values, and clay loam textures.

Hemaruka map units

HU:E1 - This is the only Hemaruka unit mapped. It occurs in the same general area, and in association with the HDHU map unit. The most noticeable feature is the eroded pits which generally cover more than 50% of the unit area. In the non eroded portions, Hemaruka and the Brown Solod (HDY) occur in about equal proportions. More than half the area has underlying bedrock at less than 5 m, while under the remainder of the map unit it is from 5 to 10 m below the surface. Both units have slopes in the 3 to 7% range.

Land use

This unit is unsuitable for both arable dryland farming and irrigation because of the solonetzic structure and lack of A horizon. These characteristics also result in a low carrying capacity for grazing.

2.6.22 JOANTO (JAT) SOILS

General setting and description

Joanto soils were mapped only in the Milk River Upland, associated with a lacustrine area which is a westward extension to the unnamed lake in the west central part of Twp 3, Rge 19. This area is poorly drained with an overall level to very gently undulating topography, except where the meandering stream dissects the valley. About 130 ha were mapped in this broad valley.

This soil is classified as a Rego Humic Gleysol. It has a 15 cm thick, very dark gray Ah horizon, overlying a strongly gleyed C horizon. Both horizons have a clay loam to clay texture. Lime may occur in the A horizon, but is always present in the massive structured C horizon. Thin sand or fine gravelly lenses often occur in the mid and lower profile, increasing to a continuous coarse sand to gravel below the 1 m depth.

Joanto map units

JAT3 - This saline unit is the only Joanto soil mapped. Salinity occurs intermittently as isolated saline spots which total up to 40% of the unit. The Rego Humic Gleysol (JAT) occupies from 50 to 80% of the unit. Small amounts of a silty Chernozemic soil (SOF) may occur near the edges of the unit. Slopes range from 0.5 to 2%.

Land use

The poorly drained and wet conditions of this unit render it unsuitable for both irrigated and dryland crop production. These wet conditions, however, are an asset to grazing resulting in a high carrying capacity for the unit.

2.6.23 KARLSBAD (KBD) SOILS

General Setting and description

These soils have developed on a moderately saline lacustrine material of medium to moderately fine texture. Landform characteristics are those of a low relief, level to undulating plains. They occur in the southeastern part of the county within Verdigris Plain where their total extent is about 350 ha.

Karlsbad is classified as a Brown Solod. It is recognizeable by a dark brown columnar Bnt horizon which is overlain by an AB horizon a few cm thick. Above this, the Ah and Ae horizons are brownish colored and have loam to silt loam textures. Total thickness of A horizon is usually about 10 cm with the major portion being Ah. Below the Bnt, colors gradually become lighter especially in the lime horizon at or near the 35 cm depth. The Bnt and lower horizons have a silty clay loam texture, as well as a moderately alkaline reaction. Slightly acid conditions prevail in the A horizon.

Karlsbad map units

KBD1 - This unit is the only one that was mapped. It occurs in widely separated locations and is usually associated with somewhat lower areas in the landscape. Up to 70% of the unit is the Karlsbad profile, the remaining portion being mainly the Solonetzic Brown Chernozemic soil (CHZ). Small amounts of the Brown Solodized Solonetz (WDW) may also occur. Only one topographic phase was recognized with slopes in the 1 to 3% range.

Land use

Low precipitation and the solonetzic structure are the main limitations of this unit, resulting in a marginal rating for dryland farming, and a relatively low grazing carrying capacity. The unit is rated as fairly good for irrigation.

2.6.24 KEHOL (KHO) SOILS

General setting and description

Kehol soils have developed on moderately saline lacustrine materials with medium to moderately fine textures. Associated landform characteristics are those of a gently undulating to undulating plain. These soils generally occur along the transitional area from the Verdigris Plain to the Milk River Ridge. Their total extent is slightly less than 700 ha.

Classified as a Dark Brown Solodized Solonetz, this soil can be recognized by its hard columnar round topped Bnt horizon. This horizon occurs at about the 20 cm depth and has a silty clay loam to silty clay texture and a dark brown color. The overlying A horizon consists of a 15 cm thick Ah which grades into an Ae horizon a few cm thick. Below the Bnt, the Cca horizon usually occurs near the 50 cm depth in a brownish gray silty clay loam. Salts are often encountered at these depths as well. Slightly acid to neutral pH values in the A horizon change to mildly alkaline in the B horizon and moderately alkaline in the C horizon.

Kehol map units

KHO3 - This saline unit is the only Kehol map unit that was recognized. In addition to the 20 to 30% content of the saline phase of the Orthic Dark Brown Chernozemic soil (LLD), small amounts of other saline soils can also be found. However, Kehol is the dominant soil. Significant amounts of the Dark Brown Solod (AWD) are also present. One area of Kehol just south of Milk River town has considerable sandy soils included in the unit.

Only one topographic phase was mapped with slopes in the 1 to 4% range. Of this about 40% had bedrock occurring at less than 5 m below the surface.

Land use

Salinity is the major limiting factor to the agricultural uses of this unit. This coupled with its solonetzic characteristics make it nonirrigable and at best marginal for dryland agriculture. Its best use is grazing despite only a poor to fair rating.

2.6.25 KLEMENGURT (KGT) SOILS

General setting and description

Klemengurt soils are moderately well drained, black grassland soils which have developed on fine textured lacustrine materials. About 200 hectares were mapped on the Milk River Ridge near the west central edge of the county. This soil occurs in valley bottoms on relatively flat topography where surface drainage is rather slow.

Classified as a Black Solonetz, this soil has a thin (3 cm) Ah horizon which is very dark gray in color. Below it, the strongly structured B horizon is very hard, black in color, and has a clay texture. The lower B is more friable than the upper B and is grayish brown in color. Clay loam textures persist and often become finer in the C horizon near the 50 cm depth. At this depth no defineable structure can be detected, and dark grayish brown colors prevail. Near the 90 to 100 cm depth a few mottles can be observed, indicative of poor subsoil drainage. Weakly calcareous conditions in the upper profile gradually increase to moderately calcareous in the lower profile.

Klemengurt map units

KGT1 - This unit, the only one mapped, is relatively pure with about 80% of the unit containing Klemengurt soils. Variations tend mainly towards the Solodized Solonetz member where Ah horizons are thicker. A few saline and gleyed variants may occur in widely separated parts of the unit. Near the valley edges, Black Chernozemic soils on till (BZR, RFD) may occur as extensions from the adjoining upland areas. Although only one topographic phase was mapped (KGT1/2) with slopes less than 2%, parts of this unit may tend towards slightly steeper slopes.

Land use

Because of their structural characteristics, Klemengurt soils are unsuitable for cultivated agriculture, either dryland or irrigated. Grazing is the best use even though the carrying capacity is low.

2.6.26 KNIGHT (KNT) SOILS

General setting and description

These well drained black grassland soils have developed on moderately coarse textured gravelly ice-contact or fluvial materials. Knight soils are concentrated in the western portion of Township 3, Range 19 where they occur on the northern slopes of the broad valley forming part of the headwaters to Mackie Creek. Their landscape setting is a low hummocky to rolling landform situated between the till upland area and lacustrine soils in the valley floor (Fig. 20). About 400 hectares of Knight soil were mapped in Warner County.

Knight soils are classified as Orthic Black Chernozemic soils. They can be recognized by the variable amount of fine gravel present in all parts of the profile. In the upper horizons, the gravel content is generally less than 10% by volume, compared to a 20% content below the 50 cm depth. Soil colors in the 10 cm thick surface horizon are generally very dark grayish brown to black in a gravelly sandy loam. The B horizon retains the gravelly sandy loam texture but colors are dark brown grading to pale brown in the lime horizon at about the 70 cm depth. At these lower depths the texture is gravelly loamy sand. Although these soils are friable when moist, they tend to become hard upon drying particularly in the B horizon.

Knight map units

KNT1 - This is the only Knight unit that was mapped in Warner County. It is a relatively pure unit, having 70 to 80% Knight soils. Inclusions of till soils (BZR, RFD, PUR) may be found near the upslope edges of the unit where it adjoins the upland till areas. Minor amounts of lacustrine soils (SOF) do occur within this unit, particularly towards the downslope portions of the landscape. This unit was mapped only on topography with slopes in the 6 to 9% range.

Land use

The sandy and gravelly nature of this soil limits its water holding capacity, thus rendering it marginal for arable dryland agriculture. Likewise the texture lowers its carrying capacity for grazing purposes. This unit is also rated rather low for irrigation, again because of the coarse texture. Presently, a large portion of the Knight map unit is used for grazing, probably its best use.

2.6.27 KESSLER (KSR) SOILS

General setting and description

Kessler soils have developed on a moderately coarse textured fluvial material. Their associated landform is primarily undulating with both hummocky and ridged tendencies. They occur mainly on the Milk River Plain in two general areas. The major portion is concentrated in the broad valley formed by the Milk River, primarily from the town of Milk River westward (Fig. 30). Lesser amounts are encountered in an area a few km northwest of Raymond. In total Kessler soils amount to almost 4000 ha.

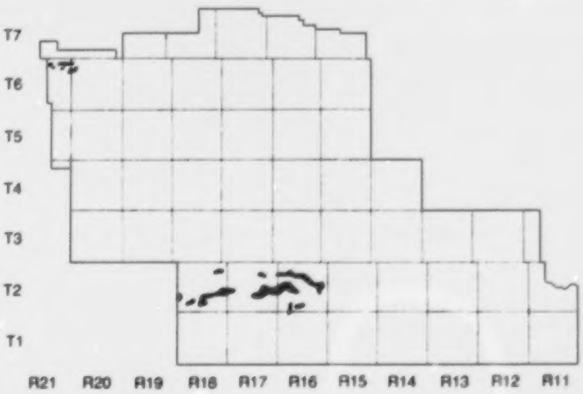


Fig. 30. Distribution of Kessler soils.

This soil is classified as an Orthic Dark Brown Chernozemic soil. Deep sandy loam materials and brownish colors are typical of Kessler soils. A dark grayish brown Ah horizon, about 15 cm thick, grades into a dark yellowish brown Bm horizon, which like the Ah, has a sandy loam texture. This texture continues through the yellowish brown lime horizon, at about 60 to 70 cm, and into the paler brown lower horizons. Relatively weak structures persist through the entire profile, although it becomes hard when dry. Neutral pH values in the upper horizons turn to mildly alkaline values in the lime horizon and below. A detailed description of a Kessler profile is included in the Appendix.

Kessler map units

KSR1 - This unit accounts for about 40% of all the Kessler soils, most of it occurring in the fluvial materials of the valley west of Milk River town. Lesser amounts can be found northwest of Raymond where a ridged landform dominates the landscape. The unit is almost entirely composed of the Kessler profile with only small areas where the underlying till is within 1 m of the surface.

Two topographic phases were recognized:

(a) KSR1/3 with slopes of 2 to 5%; about 630 ha were mapped.

(b) KSR1/4 with slopes of 6 to 9%; about 840 ha were mapped.

KSR2 - About 12% of the Kessler soils belong to this unit. It occurs only in the area west of Milk River town in a few isolated areas which tend to be lower than the surrounding landscape. Often these areas are associated with indistinct drainages which traverse the valley. The unit therefore has, in addition to the dominant Kessler, a significant amount of wet areas where Gleysolic or gleyed soils appear. Some of these wet areas may contain water particularly in the early part of the growing season.

Only one topographic phase was recognized with slopes in the 2 to 5% range. Of the nearly 500 ha mapped, 100 ha has underlying bedrock within 5 m of the surface.

KS:G1 - This unit which occurs on both sides of the Milk River west of the town, accounts for about 1/3 of the Kessler soils. It differs from the other Kessler units mainly in the composition of the material on which it has developed. This material, although being a sandy loam, has a 10 to 15% content of very fine gravel throughout the profile.

The gravelly phase of Kessler is the dominant soil in this unit. Inclusions of other sandy Chernozemic soils (MGR, FOR) may occur. Areas of rougher topography usually have some Rego Chernozemic soils, as well as tending towards a loamy sand texture, especially in the lower profile.

Two topographic phases were recognized:

(a) KS:G1/3 with slopes of 2 to 5%; about 1150 ha were mapped all with underlying bedrock at less than 5 m.

(b) KS:C1/4 with slopes of 6 to 9%; about 170 ha were mapped all with underlying bedrock at less than 5 m.

KSMG1 - This unit accounts for about 15% of the Kessler soils. It occurs primarily on the north side of the Milk River, both east and west of Milk River town. More than half the unit has Kessler soil, with up to 50% having underlying till is at less than 1 m (Migra soil).

Two topographic phases were recognized:

(a) KSMG1/3 with slopes of 2 to 5%; about 330 ha were mapped.

(b) KSMG1/4 with slopes of 6 to 9%; about 200 ha were mapped.

KSOA1 - About 2% of the Kessler soils have been included in this unit. It occurs only in the area northwest of Raymond. The unit is composed of two closely associated soils; Kessler which is dominant, and Oasis, which has developed on a veneer of loam to silt loam overlying sandier material. The unit may also have inclusions of deeper silt loams (LET). A ridged landform is associated with this unit.

Only one topographic phase was recognized with slopes in the 2 to 5% range.

Land use

Texture is the main limitation of Kessler units to their agricultural use. This is especially true of the KS:G1 units which are marginal to poor for arable dryland agriculture and have a low grazing rating. They are also considered to be nonirrigable. The remainder of the Kessler units are fairly good for both dryland agriculture and grazing. They are considered to be good irrigation soils with the exception of the KSR2 unit which has a fair rating because of the wet areas which form part of this unit.

Most of the Kessler units being cultivated are performing satisfactorily with good management. However, parts of the KS:G1 unit are suffering from wind erosion, especially where textures tend to be coarser than normal.

2.6.28 LETHBRIDGE (LET) SOILS

General setting and description

These soils have developed on a deep uniform lacustrine material of medium to moderately fine texture, usually deposited in a level to undulating plain (Fig. 25). Where topography is rougher, it has a ridged or subdued hummocky landform. Lethbridge soils total about 5500 ha concentrated primarily in three areas on Verdigris Plain (Fig. 31). The largest is associated with the lacustrine basin in the northwest part of the county. Another lies along the southern boundary of Verdigris Plain about 9 km west of Warner. The third is associated with the Milk River occurring near the junction of the north and south branches of this river.

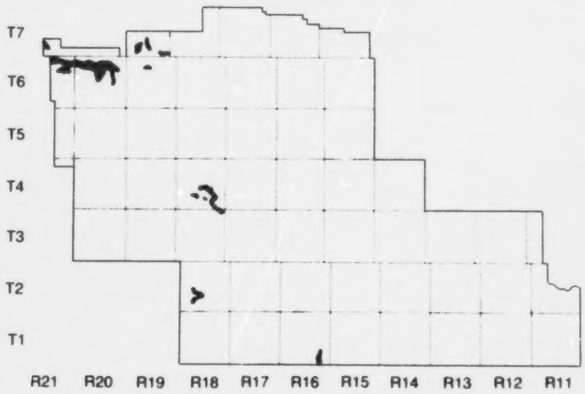


Fig. 31. Distribution of Lethbridge soils.

Lethbridge is classified as an Orthic Dark Brown Chernozemic soil. Normally the Ah horizon is about 15 cm thick. It grades into a brighter brown and finer textured Bm horizon, which is further characterized by its prismatic structure. Below this, at about the 45 cm depth, is a moderately calcareous subsoil. Silt loam to silty clay loam textures are usual for the lower subsoil. Close to neutral pH values occur in the upper part of the profile, yielding to mildly alkaline conditions in the subsoils. A detailed description of a Lethbridge soil is included in the Appendix.

It has been observed that Lethbridge soils in irrigated areas usually have darker colors than their non irrigated counterpart, particularly noticeable in the A and B horizons. Furthermore, electrical conductivity measurements indicate that these irrigated soils often have low levels of salinity in the B and C horizons, too low to be visually detected.

Lethbridge map units

LET1 - Most of this unit occurs in the northwestern part of the county on the south side of the lacustrine basin. Lesser amounts occur west of Warner. Combined, these areas of LET1 comprise about 1/4 of the Lethbridge unit total.

Lethbridge is the dominant soil in this unit. A significant portion of the unit may have underlying till at less than 1 m, WNY (Whitney) soils. Inclusions of finer textured soils (CLD) may occur as can minor amounts of salinized soils (LLD). Generally the LET1 units west of Warner are texturally less uniform and a little coarser textured than the units near the lacustrine basin.

Only one topographic phase was recognized with slopes in the 1 to 4% range. Of this the majority (1160 ha) had underlying bedrock at depths greater than 5 m, while under the remaining 160 ha it was less than 5 m below the surface.

LET3 - Like LET1, this unit occurs in the two major Lethbridge soil areas, occupying a little less than 1/4 of that total. The major portion was mapped west of Warner.

Although the Lethbridge profile is dominant, the units most striking feature is the presence of salinized soil (LLD) which may occupy up to 40% of the unit. Inclusions of fine textured and shallower lacustrine materials are common. Like the LET1 unit, the materials are also less uniform and coarser in the LET3 units west of Warner, compared to those near the lacustrine basin.

This unit occurs on one topographic phase only with slopes ranging from 1 to 4%. Bedrock is at depths greater than 5 m under about 1100 ha, most of which lies west of Warner. About 180 ha has bedrock at shallower depths, all occurring near the lacustrine basin.

LEKS2 - This unit occurs in one area only where it occupies 140 ha on the east side of the town of Stirling. Lethbridge, the dominant soil can usually be found on the lower landscape positions. A coarser, sandy loam soil (KSR) which comprises up to 30% of the unit generally occurs on the hummocky landscape positions. Of great significance to the unit is the 20 to 30% low areas of gleyed and gleysolic soils, many of which contain water. Minor portions of the unit contain a coarser textured till-like material. One topographic phase was recognized with slopes in the 6 to 9% range.

LEKS6 - About 7% (380 ha) of the Lethbridge soils belong to this unit. It occurs in an area a few kilometres north of Stirling, which has an undulating to hummocky landform with some ridged tendencies. Slopes range from 3 to 8%.

The entire unit has been influenced by coarser textured components of both the dominant (LET) and the subdominant (KSR) soils. Some of the Kessler soils differ from the normal profiles by having significant amounts of coarse sand to fine gravel in the lower part of the profile. In addition, the unit has a 20 to 30% content of soils developed on fluvial gravels (NED). Generally, the coarser textured soils are associated with the rougher topographic segments of the landscape.

LEOA1 - This is the most extensive of the several Lethbridge map units, amounting to about 43% of the total Lethbridge soils. It occurs primarily in the area associated with the lacustrine basin in the northwest part of the county. Lesser amounts were mapped in the area associated with the Milk River. Landforms vary from gently undulating to steeper sloping units, some with ridged, and some with dissected characteristics.

Lethbridge, the dominant soil, generally occurs in the lower landscape positions. About 1/3 of the unit has a coarser, sandy subsoil (OAS) and can be found on higher positions. Where ridged landforms are most prominent it is not unusual to find inclusions of sandy loam (KSR) soils on the higher landscapes. Thus both surface and subsoil textures gradually become finer going from higher to lower landscape positions.

Two topographic phases were recognized:

(a) LEOA1/2-3 with slopes of 1 to 4%; covers 2150 ha.
(b) LEOA1/4D with dissected slopes of 6 to 9%; covers 200 ha located near the junction of the north and south branches of the Milk River.

Land use

Most Lethbridge units have no severe limitations to their agricultural use except for the saline units which are non irrigable and marginal for dryland agriculture. Topography is a limitation only in the dissected unit which is also non irrigable. All Lethbridge units potentially have a high grazing carrying capacity.

Except for those adjacent to the Milk River, all units are presently under cultivation. A large percentage are successfully being irrigated. However their location in a lower heat unit area restricts the crop selection to generally non specialty crops.

2.6.29 LILYDALE (LLD) SOILS

General setting and description

These are soils which have become salinized by either dryland saline seep or by seeping irrigation water. Although they occur as isolated and discontinuous areas, their occurrence is almost exclusively within Verdigris Plain where proximity to bedrock limits groundwater flow. These soils are usually moist from seeping ground or irrigation waters. Lilydale soils are generally found in areas of low relief (Fig. 32) and gently undulating topography, and are associated with the stone free lacustrine or fluvial parent material on which they have formed. Sometimes they occur in elongated areas along low draws, or in areas of irregular configuration. Whatever their size and shape, Lilydale soils, in cultivated areas, occur either as bare salt crusted areas, or with a cover of weeds, mainly kochia (Plate II-E). In Warner County about 2250 ha of Lilydale soil were mapped.

Fig. 32. A Lilydale soil area. Note salts on the surface.

Lilydale soils are Orthic Chernozemic soils, either Brown or Dark Brown, which have become salinized. This is evident by the saline conditions of the A, B, and C horizons. The profile has a dark grayish brown A horizon about 15 cm thick which has a fine granular structure, and a loam to silt loam texture. The B horizon, ranging in thickness from 15 to 30 cm, has a weak prismatic structure and a silt loam to silty clay loam texture. Lime usually occurs at about 50 cm or more in a material with a loam to silt loam texture. Strongly saline conditions in the A and B horizons, decrease to moderately saline in the C horizon. These salts become visible as salt flecks if and when the profile dries. A detailed description of a Lilydale soil is included in the Appendix.

Lilydale map units

LLD1 - Within this unit the saline Chernozemic soil (LLD) occupies from 50 to 70% of the unit. Between 15 to 30% of the soils will be Orthic Humic Regosols, saline phase. These saline soils occur in close association with one another and cannot be associated with any particular landscape feature. Towards the edges of the unit, and on slightly higher landscape positions where soils may not have been affected by salinity, Orthic Chernozemic soils may occur. Small amounts of gleyed phases and Gleysolic soils may exist in the lower landscape positions.

All Lilydale soils mapped in Warner County were found on topography with slopes ranging from 0.5 to 4%. Approximately half of the total Lilydale area has underlying bedrock occurring within 5 m of the surface (LLD1/ 2-3:R).

Land use

Because of their saline conditions, Lilydale soils cannot be used for either dryland or irrigated agriculture. However, these salinized soils have a good potential for reclamation using tile drains. This procedure has already reclaimed some Lilydale areas which were salinized by dryland seepage rather than by irrigation. The saline conditions of Lilydale soils lowers their grazing carrying capacity to a relatively low level.

2.6.30 LUPEN (LUP) SOILS

General setting and description

Lupen soils were mapped in that portion of the Milk River Upland lying south of the river, where their total extent is about 500 ha. They have developed on a veneer of medium to moderately fine textured lacustrine material overlying till. These soils can generally be found on a gently undulating to undulating plain.

Lupen is classified as an Orthic Dark Brown Chernozemic soil. It has a dark grayish brown A horizon, about 10 cm thick which has a loam to silty clay loam texture. There is a gradual change into the darker brown B horizon which has a silty clay loam texture and a strong prismatic structure. Near the 30 cm depth colors change gradually to the yellowish brown C horizon, also with silty clay loam textures. Till is often encountered at about 50 cm. Lime which is present in the till may sometimes occur a few centimetres above the till. At the surface, pH values are neutral changing to mildly alkaline in the B horizon and moderately alkaline in the lime horizon.

Lupen map units

LUP1 - Only one unit was recognized. The Lupen soil is dominant comprising well over half the soils in the unit. Occasionally the underlying till reaches the surface (PUR soils). Conversely in some locations the till may be covered by more than 1 m of lacustrine material which, in some areas, ranges to silty clay in texture.

This map unit occurs in two distinctly different landscape positions. One was a small isolated super-glacial lacustrine areas within a hummocky morainal upland. These areas are at elevations approximating those of the surrounding hummocky till. The second occurs as larger lower lying areas associated with ill-defined drainage ways. The surface form is similar in both situations with gently undulating slopes in the 1 to 4% range.

Land use

Lupen soils are good agricultural soils. Their main limitation is the relatively short frost-free period associated with the Milk River Upland, which results in only a fair rating for irrigation. This climatic limitation also restricts the choice of crops for dryland farming. This unit has a relatively high grazing rating.

2.6.31 LONELY VALLEY (LVY) SOILS

General setting and description

Lonely Valley soils are moderately well drained, black grassland soils which have developed on a medium textured fluvial material. They were mapped on the continuous apron of material along the sides of Lonely Valley, a glacial spillway occurring in the Milk River Upland. They occupy about 150 ha in the extreme southwest corner of Warner County.

Lonely Valley soils are classified as Orthic Black Chernozemic soils. The 6 cm thick, dark grayish brown A horizon has loam texture and gradually merges into the underlying browner B horizon which has a weak prismatic structure. This horizon is usually about 20 cm thick in a loam to clay loam material. Similar textures continue into the grayish brown lime horizon near the 30 cm depth. It is not uncommon to find lenses of coarser material in this soil, particularly below the 50 cm depth.

Lonely Valley map units

LVY1 - Despite having some textural variability, this was the only unit mapped within Lonely Valley. The previously described soil, although dominant, may have textural variations depending on its location and proximity to the valley sides. In the central portion of the valley, profiles most closely, resemble the described soil. However, closer to the valley edges where fan and forms are most noticeable, textures are more variable tending towards the coarser variants. Saline phases and gleyed variants occur in small amounts along an indistinct stream meandering through the valley. Concentrations of solonetzic soils may also be found in parts of the valley, however, these soils do not exceed 20% of the unit. As slopes are generally less than 2% and only one topographic phase (LVY1/2) was recognized.

Land use

Although no arable agriculture is presently practiced on Lonely Valley soils, they are suitable for coarse grain production. The frost-free period of less than 90 days makes this soil unit undesirable for irrigation, at least for crops normally grown under irrigation in southern Alberta. This unit has good capability for grazing as it requires less than 10 ha per animal unit year.

2.6.32 MALEB (MAB) SOILS

General setting and description

About 3/4 of the soils on Chin Plain belong to the Maleb group of soils. (Fig. 33). However, their total of approximately 60,000 ha is only 13% of the total county area. These soils have developed on weakly saline till deposits either on undulating ground moraine or on a gently rolling to hummocky end moraine. Dryland saline seeps are not common in Maleb soil areas.

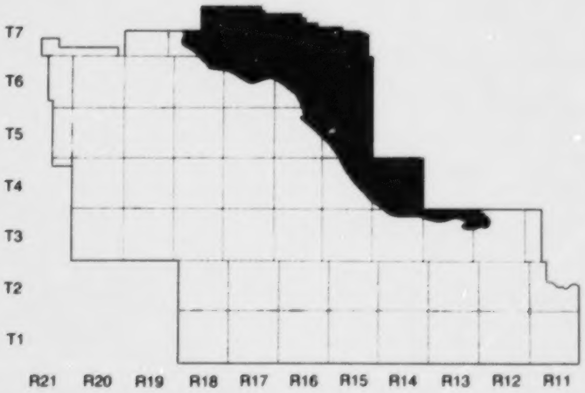


Fig. 33. Distribution of Maleb soils.

Maleb is classified as an Orthic Brown Chernozemic soil (Plate II-F). It has a brown A horizon from 10 to 15 cm thick which has a loose granular structure. The change to the dark brown prismatic B horizon is gradual. A light gray strongly calcareous lime horizon occurs near the 35 cm depth. Textures gradually change from loam at the surface to clay loam in the C horizon. Pebbles and stones are evident throughout the profile which ranges from neutral pH values at the surface to moderately alkaline at depth. A detailed description of a Maleb profile is included in the Appendix.

In most cultivated Maleb areas, there is generally considerable variation in profile depth. On downslope landscape positions, profiles will often have A horizons up to 25 cm or more in thickness with correspondingly thicker B horizons and greater depth to lime. It is assumed that this variability is the result of years of slopewash activity accumulating materials in lower landscape positions. These slopewash materials are often hard to distinguish from lacustrine materials of equivalent texture.

Maleb map units

MAB1 - This unit which consists dominantly of the Maleb soil is fairly general in the Maleb soil area. On rougher portions of the unit, minor amounts of Rego Chernozemic profiles may occur. A few lower landscape positions with a veneer of lacustrine material have the Cranford soil present. These latter two soils however occupy less than 10% of the unit. Occasionally the unit will have low poorly drained areas where Gleysolic soils occur. About 5000 ha were mapped all with slopes in the 3 to 7% range.

MAB2 - The most significant characteristic of this unit is the numerous low poorly drained areas in which sloughs or Gleyoslic soils occur. This portion of the unit accounts for 20 to 30% of the unit area. However, Maleb is still dominant. Inclusions of Cranford as well as Rego Chernozemic soils will occur, the latter particularly in units with steeper slopes.

More than 1/4 of the Maleb soils belong to this unit. It occurs primarily within a series of long northwest-southeast trending end moraines on the north side of Etzikom Coulee. These end moraines also occur on the south side of Etzikom Coulee, towards the east side of the county. There, they have a similar elongated and directional trend, but are not as continuous and often have a more irregular shape. A hummocky surface form is typical of this unit, and is most evident in the units with steeper slopes.

Two topographic phases were recognized:

(a) MAB2/3 with slopes of 2 to 5%; covers about 2700 ha.
(b) MAB2/4 with slopes of 6 to 9%; covers more than 14000 ha.

MAB4 - Along with the dominant Maleb profile this unit has a significant amount of its area occupied by Rego Brown Chernozemic soils. They occur near or at the top of steeper slopes where soils erosion is and has been most active. A large percentage of these steep slopes are associated with a hummocky landform resulting in some low poorly drained areas where Gleysolic soils may be found. A considerable portion of these hummocky units occur along Etzikom Coulee. MAB4 units are also found on some long ridges south of this coulee towards the east side of the county. About 3100 ha were mapped all with slopes in the 6 to 9% range.

MAB7 - Less than 1% (about 300 ha) of the Maleb soils belong to this unit. It occurs in the eastern part of the county, on the western flank of what is locally known as the Lucky Strike Upland, a bedrock controlled high about 15 km north of Writing-On-Stone Provincial Park. Up to 50% of the unit may contain Solonetzic soils (HUR and HDY) as well as some Solonetzic Brown Chernozemic soils. However, Maleb is still the dominant soil. One topographic phase was recognized with slopes of 6 to 9% on a hummocky and inclined landform.

MA:P1 - The most noticeable feature of this unit are the numerous stones and boulders inbedded in the surface. The soil component is largely the stony phase of Maleb, with minor amounts of other non-stony Chernozemic soils. Two areas were mapped totalling about 560 ha. The larger area lies along the south bank of Etzikom Coulee near the eastern county boundary. The second area lies along the south bank of Chin Coulee near the northern boundary of the county. Both areas have a hummocky to ridged surface form with slopes in the 6 to 9% range.

MACF1 - Of the several Maleb map units, this is the most extensive, covering about 26,000 ha, or about 38% of the total Maleb soil area. It is widespread on Chin Plain, occurring generally as large elongated areas between the series of end moraines discussed earlier. These inter-moraine areas have an undulating surface form composed of ground moraine (Maleb soils) and a discontinuous veneer of medium textured lacustrine material (Fig. 22) (Cranford soils). A few of the lower areas will contain Gleysolic soils. Slopes on this unit range from 2 to 5%.

MACF2 - This unit is very similar to the MACF1 unit, differing only is the occurrence of 15 to 30% of low wet areas where Gleysolic soils or sloughs occur. These low areas are associated with a subdued hummocky landform. Generally, this unit borders a MAB2 area, lying between it and a MACF1 area, thus it has a similar elongated configuration. About 11,000 ha were mapped all with slopes in the 2 to 5% range.

MACF7 - This unit occurs on the western flank of the Lucky Strike Upland and contains a significant amount of Solonetzic soils on both the till and lacustrine veneer. As with other MACF units, the shallow lacustrine soils usually occupy the lower and smoother topographic positions. The total extent of this unit is about 35 ha, all on slopes in the 2 to 5% range.

Land use

Low precipitation is the main limiting factor to dryland crop production and grazing on most Maleb map units. Despite this, almost all Maleb soil areas are under cultivation mainly for grain production. For irrigation, only the "1" units are well suited, the other units are less desirable or non irrigable. The "2" units because of the numerous sloughs; and the P1 unit, because of the stones, are non irrigable. Both "7" units are poor for irrigation because of the Solonetzic soils. A lower fertility level in the MAB4 unit results in a less desirable irrigation soil. The stony condition of the:P1 unit makes it unsuitable for anything but grazing.

2.6.33 McNAB (MCN) SOILS

General setting and description

McNab soils occur within spillway valleys where they have developed on medium to moderately fine textured materials of variable salinity. These materials have been deposited as fluvial aprons along both sides and within the valley bottom (Fig. 10). About 2230 ha of these well drained soils have been mapped in Warner County, primarily in Verdigris Coulee. Lesser amounts occur in Black and Etzikom coulees. Greasewood shrubs dot the landscape in the more alkaline portions of Black Coulee. All McNab soils are found on slopes of 0-3%.

Because these soils have little or no A horizon and no B horizon they have been classified as Orthic Regosols. There is strong evidence of layering or banding in the subsoil which is variable in both thickness and texture. Medium to low concentrations of lime are present throughout the profile.

McNab map units

MCN3 - This unit which occupies about 25% of all McNab soil areas, occurs primarily in Verdigris Coulee. Lesser amounts occur towards the east end of Black Coulee and near the northern extreme of Etzikom Coulee. The unit contains 50% or more of the McNab soil and up to 40% of the saline phase of McNab. Minor occurrences of saline Chernozemic soils may occur as well as gleyed variants or Gleysols. Only one topographic phase of this unit was recognized with slopes ranging from 1 to 4%.

MCN7 - About 45% of McNab soil areas have Solonetzic characteristics of some kind. These characteristics are weakly developed and range from Solodized Solonetz to Solod through to the Solonetzic Chernozemic profiles. Although soils with these Solonetzic characteristics are significant in this unit they do not exceed 40% of the map unit. From 50 to 70% of the map unit contains the Orthic Regosol soil (MCN). Very minor amounts of gleyed variants and other Chernozemic soils may occur. The majority of this unit can be found in Verdigris Coulee, and lesser amounts in Black Coulee. As with the MCN3 unit, one topographic phase was mapped, with slopes from 1 to 4%.

MC:S1 - This unit is concentrated in Verdigris Coulee, with lesser amounts in the eastern end of Black Coulee. Together these two areas of the MC:S1 unit comprise about 30% of the McNab soils in the county. Although the unit is primarily comprised of the saline phase of McNab it may have up to 30% of the non-saline member. Slopes are generally less than 2%.

Land use

McNab soils have several characteristics which render them unsuitable for any form of arable agriculture. The main limiting factors are their low natural fertility, the saline condition of the parent material and the Solonetzic characteristics in the MCN7 unit. For these reasons, all McNab soils are being used for grazing even though it requires at least 50 ha to support one animal unit per year. Grass cover is very sparce and often absent especially where saline and sodic conditions are most severe.

2.6.34 MIGRA (MGR) SOILS

General setting and description

Migra soils are relatively insignificant in Warner County, their total extent being slightly in excess of 1000 ha. They are found within the broad valley associated with the Milk River, occurring only on the south side of the river. These soils have formed on a veneer of moderately coarse textured fluvial material overlying till. Surface features range from undulating to hummocky, a reflection of the surface form of the underlying till. Ridged tendencies can also be observed in some areas.

Migra is classified as an Orthic Dark Brown Chernozemic soil. It has a dark grayish brown A horizon about 10 cm thick which has a sandy loam texture. Although colors gradually change to dark brown in the B horizon the texture change is negligible. There is a tendency for these two horizons to become hard when dry even though there is little discernible structure. Near the 40 cm depth there is a change to more yellowish brown colors. Till is usually encountered at the 50 cm depth or deeper, a depth at which lime also occurs. The pH values increase from near neutral at the surface to mildly alkaline through the fluvial material. In the underlying till these values are in the moderately alkaline range.

Migra map units

MGCR1 - This unit was mapped about 4 km south of Milk River town. It lies at the southern edge of the fluvial valley, adjacent to the till area bordering the valley. Thus the unit, in addition to the dominantly Migra profile, has a significant inclusions of soils developed on till (CRD), which occurs on higher landscape positions (Fig. 17). Minor inclusions of deep sandy soils may occur. About 850 ha were mapped on slopes in the 3 to 7% range.

MGHR1 - Only 200 ha of this unit was mapped, in an area about 5 km southwest of Milk River town. It was separated because a significant portion has deep fluvial loamy sands (Heartbreak soils). However the unit is still largely the Migra profile. Ridged tendencies which are peculiar to this unit can be associated with the Heartbreak soil. One topographic phase was recognized with slopes of 6 to 15%, bedrock occurs within 5 m of the surface.

Land use

The MGCR1 unit is being cultivated, but there is evidence of wind erosion and the use of conservation practices is very important. These coarse textures also limit the carrying capacity of these soils for grazing. The MGHR1 unit is considered non irrigable because of topography and the occurrence of bedrock at shallow depths.

2.6.35 MILK RIVER (MKR) SOILS

General setting and description

Slightly more than 4000 ha of these soils were mapped along the floodplain of the Milk River. Materials along the entire length of the valley are recently deposited alluvium (or fluvial material) composed of very coarse to moderately coarse deposits. The river valley has an overall flat appearance, but is in fact cut up by the strongly meandering stream (Fig. 34), which has left numerous meander scars and oxbow lakes. Although most of the valley is grassland, stands of western cottonwood as well as dense thickets of thorny buffaloberry have become established in moist locations.

Fig. 34. Valley of the Milk River.

Most of the Milk River soils are Cumulic Regosols with a weak A horizon. This horizon is a few centimetres thick and generally has a sandy loam to loamy sand texture. Below this, the profile consists of layers of sandy loam to loamy sand interspersed with sandy, gravelly and sometimes silty layers. In some locations buried Ah horizons may be found. With depth, the frequency and thickness of the gravel layers increases, often to continuous gravel below the 1 m depth. Although there is great variability in layer thickness, most are from 25 to 40 cm thick. A grayish brown color is most prevalent, with low to medium concentrations of lime throughout the profile.

Milk River map units

MKR1 - Only one Milk River unit was mapped in the county. Variations are mainly those that can be attributed to material differences. Up to 30% of the unit has Orthic Regosolic soils which differ from the dominant Cumulic Regosol in having no buried Ah horizons, and no depositional layering. Small amounts of soil may be found where a weakly developed Chernozemic profile has developed. Since the western portion of this unit lies within the Dark Brown Soil Zone, surface colors are generally a little darker than farther east. Only one topographic phase was mapped with slopes from 2 to 5%.

Land use

The Milk River unit has little or no value for either dryland or irrigated crop production mainly because of the dissected landscape created by the meandering river. Its best use is grazing, which is even more attractive because of the adequate water supply. However, because of the low water holding capacity of the coarse textured soils the carrying capacity is rather low, about 35 ha per animal unit year. A poor quality gravel may be available in a few locations.

2.6.36 MASINASIN (MSN) SOILS

General setting and description

These are Brown soils developed on medium to moderately fine textured, and moderately calcareous till materials. They occupy over 12 000 ha in the eastern part of Verdigris Plain (Fig. 35). Both finer and coarser textured variants occur, the former primarily in the northern part and the latter in the southern part. Although more than 2/3 of these well drained soils occur on an undulating ground moraine, there are areas with hummocky and ridged landforms. Erosion on these steeper slopes often results in slopewash accumulation on lower slope and valley positions. A considerable portion of the Masinasin soils have underlying bedrock sufficiently close to the surface to influence the surface landform and relief.

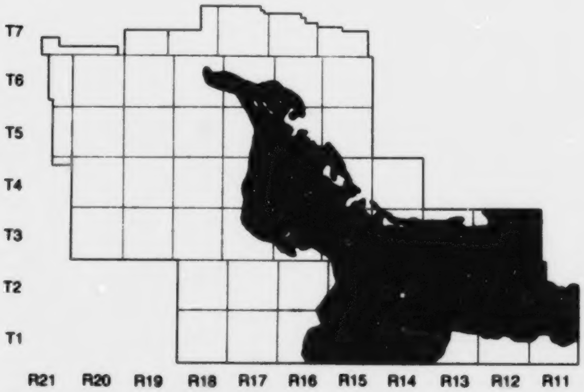


Fig. 35. Distribution of Masinasin soils.

Masinasin, classified as an Orthic Brown Chernozemic soil, has a brownish colored solum. Textures gradually become finer with depth changing from loam in the A horizon to loam to clay loam in the C horizon. Usually these soils have a relatively high silt content. Depth to the calcareous subsoil ranges from 25 to 40 cm. The profile is moderately structured and quite friable throughout. A mildly alkaline reaction in the A and B horizons changes to moderately alkaline in the lime horizon and below. A detailed description of a Masinasin soil is included in the Appendix.

Masinasin map units

MSN1 - Nearly 1/3 of the Masinasin soils belong to this unit, which is composed almost entirely of the Masinasin profile. Units with rougher topography often have a 10% inclusion of the Rego Chernozemic profile (CLR). Occasionally, the unit will contain low poorly drained areas in which Gleysolic soils occur.

In the northern part of the Masinasin soil area, along the boundary between the Verdigris and Chin plains, soils often have a tendency towards finer than normal textures. This is particularly noticeable on units with ridged tendencies and steeper slopes.

Two topographic phases were recognized:

(a) MSN1/3 with slopes of 2 to 5%; covers about 23,000 ha. Of this about 15% has underlying bedrock within 5 m of the surface.

(b) MSN1/4 with slopes of 6 to 9%; covers about 16,000 ha. Of this about 10% has underlying bedrock within 5 m of the surface.

MSN2 - This unit, amounting to about 2100 ha, occurs in widely separated locations. One important feature is the 15 to 30% content of low poorly drained areas where Gleysolic soils or sloughs occur. Landscape features are those of a hummocky moraine in which the dominant soil is Masinasin. On the tops of the steeper knolls, the Rego Chernozemic soil (CLR) can be found. This latter soil however does not exceed 20% of the unit. This unit was mapped on one topographic phase only with slopes in the 6 to 9% range.

MSN3 - Total extent of this unit is a little more than 1% of the total Masinasin soil area. Saline soils comprise from 20 to 40% of the unit. This salinity, present primarily as the salinized phase of the dominant soil Masinasin, is concentrated on lower slope positions. Minor amounts of the Rego Chernozemic soil (CLR) usually occur on steeper slopes. This unit occurs in isolated areas at various locations within the Masinasin soil area.

Two topographic phases were mapped:

(a) MSN3/3-2 with slopes of 1 to 4%; covers about 1600 ha. Of this about 40% has bedrock within 5 m of the surface.

(b) MSN3/4-3 with slopes of 4 to 7%; covers about 100 ha.

MSN4 - This unit, representing about 11% of the Masinasin soils occurs in areas of rougher topography. Although it can be found throughout the Masinasin soil area, it is concentrated along spillways and banks of drainage channels. Masinasin, the dominant soil can be found on the mid and lower sloper positions. From 20 to 40% of the soils are Rego Chernozemic (CLR) and occupy the upper slope positions. Accelerated erosion due to cultivation has removed much of the original topsoil from steeper slopes. Thus, when this unit is cultivated the tops of knolls have a grayish color where the lime horizon has been exposed.

Two topographic phases were recognized:

(a) MSN4/4 with slopes of 6 to 9%; covers about 12,800 ha.

(b) MSN4/5 with slopes of 10 to 15%; covers about 1100 ha.

MSN6 - Although this unit can be found in several locations within the Masinasin soil area, it is concentrated in the area between the Milk River and the United States - Canada border. About 7% of the Masinasin soils are included in this unit, of which more than half is found on rough topography. The significant characteristic is the 20 to 40% content of coarse textured soils found in the unit. A large proportion of these coarse soils are the gravelly phase of the Masinasin profile. In some locations an Orthic Brown Chernozemic soil on fluvial outwash (PUN) can be found. Generally, this unit has more surface stones than other Masinasin units.

Three topographic phases were recognized:

(a) MSC6/3 with slopes of 2 to 5%; covers about 3200 ha. Of this about 25% has bedrock within 5 m of the surface.

(b) MSN6/4 with slopes of 6 to 9%; covers about 3500 ha.

(c) MSN6/5 with slopes of 10 to 15%; covers about 800 ha.

MSN7 - The most significant feature of this unit is the 30 to 50% occurrence of solonetzic soils, which almost equals the amount of the dominant Masinasin profile. These solonetzic soils are almost equally divided between the Solodized Solonetz (HUK), the Solod (HDY), and the Solonetzic Brown Chernozemic soils.

Total extent of this unit is about 1750 ha. It is concentrated in an area between the Sweetgrass and Lucky Strike uplands. Slopes from these two uplands are towards the Milk River which flows between them. Thus the unit is often on inclined as well as on hummocky landforms. Another characteristic of this area is that underlying bedrock is generally at depths of less than 10 m.

One topographic phase was recognized with slopes in the 6 to 9% range. About 1/3 of the unit area has bedrock at less than 5 m below the surface.

MS:P1 - This unit is characterized by its stony nature. Up to 80% of the soils are the stony phase of the Masinasin profile. Small amounts of the Rego Chernozemic soil (CLR) may be present, as well as some gravelly soils (PUN). The unit generally occurs on upland areas along the Milk River and the major spillways such as Etzikom, Verdigris and Black coulees. Stones are generally concentrated on the higher landscape positions.

One topographic phase was recognized on hummocky or rolling topography with slopes of 6 to 15%. Total extent is about 600 ha.

MSAN1 - This unit comprises about 2% of the total Masinasin soil area. It occurs in two general areas in the southern part of the county, both associated with the Milk River. The greater extent occurs southeast of Milk River town; the second east of Writing-On-Stone Park where it is also associated with Black Coulee. In this second area, most of the unit has underlying bedrock at less than 5 m particularly where rougher topography exists. (Fig. 17).

This complex unit is dominantly the Masinasin profile which generally occurs on higher landscape positions. From 20 to 40% of the unit is an Orthic Brown Chernozemic soil developed on a veneer of fluvial material overlying till (ANO). Occasionally the fluvial sandy loam may exceed the 1 m thickness. A Rego Brown Chernozemic profile (CLR), amounting to about 20% of the unit, is present on the steeper till slopes.

Two topographic phases were recognized:

(a) MSAN1/3 with slopes in the 2 to 5% range; covers about 1100 ha. Of this about 5% has bedrock within 5 m of the surface.

(b) MSAN1/4 with slopes in the 6 to 9 % range; covers about 1400 ha. Almost half of this has bedrock within 5 m of the surface.

MSCF1 - This is the most widespread of the Masinasin map units, covering about 37% of the total Masinasin soil area. The unit consists of two closely associated Orthic Chernozemic soils, the dominant one on till (MSN) and the subdominant one on a veneer of silty lacustrine material overlying till (CFD). The general landform is a level to undulating ground moraine with a veneer of lacustrine material infilled in the lower landscape positions (Fig. 22). In a few locations where the lacustrine material may exceed the 1 m thickness (CHN).

One topographic phase was recognized with slopes of 2 to 5% totalling 45000 ha. Of this about 10% had bedrock within 5 m of the surface.

MSCF2 - This unit is identified by the significant inclusion of poorly drained soils. These occur in the lower landscape positions and include semi-permanent sloughs. In this unit the Masinasin and Cranford soils are co-dominant, each occupying from 30 to 50% of the unit. It occurs in widely separated areas within the Masinasin soil area.

A total of 2800 ha were mapped all with slopes in the 2 to 5% range. Approximately 1/4 of this total has bedrock within 5 m of the surface.

MSCF7 - This unit has similar parent material relationships to that described in the MSCF1 unit. However, the main distinguishing feature are the Solonetzic soils which total about 1/4 of the unit area. The Solonetzic soils may be developed on till (HUK and HDY), or on the lacustrine veneer (DHS and GEM). The major portion of the unit still has Chernozemic soils including Masinasin which occupies about half the unit, and Cranford which occurs in the remaining 25%.

Like the MSN7 unit with which it is closely associated, most of this unit occurs in the area between the Sweetgrass and Lucky Strike uplands. Minor amounts occur elsewhere in widely separated areas. Its total extent is about 4300 ha all on slopes in the 2 to 5% range. Of this about 1/3 has underlying bedrock within 5 m of the surface.

Land use

A large percentage of the Masinasin soils are being cultivated. Their main limitation to dryland agricultural production is the limited amount of rainfall in the region. Because of their moderately high silt content, these soils appear to be more susceptible to water erosion than Maleb soils, particularly, those on steeper slopes. Some units have additional limitations which are sufficiently severe to make them unsuitable for continuous cropping. The main ones are salinity in the "3" units, stones in the ":P" units, as well as slopes greater than 10% (Classes 5 and 6).

Most "1" units are good irrigation areas except those with underlying bedrock within 5 m of the surface (:R units). These units must be rated lower because of the possibility of water table buildup and seepage. The coarser textured "6" units as well as those with solonetzic soils, the "7" units, are no better than fair for irrigation. All units with slopes greater than 10% (Classes 5 and 6) are considered non irrigable as are the stony (:P1) units. Others in this non irrigable class are the salinized "3" units as well as those with numerous wet areas ("2" units).

For grazing purposes, all Masinasin units have a relatively low carrying capacity, primarily because of low rainfall.

2.6.37 NEW DAYTON (NED) SOILS

General setting and description

These well drained soils have formed on a sandy and gravelly fluvial outwash material. They usually occur on a terraced landform along rivers or streams. Total extent is about 1200 ha most of which occurs within Verdigris Plain.

New Dayton is an Orthic Dark Brown Chernozemic soil. The A horizon, about 12 cm thick, has a dark brown color and a loam to sandy loam texture. Below it, the B horizon is from 15 to 20 cm thick, has a coarse sandy loam texture and a dark yellowish brown color. Lime usually occurs at the 30 cm depth in a yellowish brown, coarse sandy loam to loamy sand. Gravel increases with depth from a 10% content in the upper profile to near 80% in the lower profile. Except for a weak subangular blocky structure in the A horizon, this profile is lacking any discernible structure. At the surfaces pH values are near neutral but increase to mildly alkaline in the B horizon and moderately alkaline in the C horizon.

New Dayton map units

NED1 - Most of this unit occurs in the broad valley of the Milk River west of Milk River town. Lesser amounts can be found a few kilometres west of Highway 4 between the towns of Coutts and Milk River. Another area, was mapped in a wide portion of the Deer Creek valley which flows from the Sweetgrass Hills into the Milk River.

New Dayton is the dominant soil, occupying up to 80% of the unit. Inclusions of gravel-free fluvial deposits with either sandy loam (KSR) or loamy sand (HRK) textures may occur, in amounts of up to 20% of the unit. This unit is usually found in association with other units of coarse textured soils.

One topographic phase was recognized with slopes in the 3 to 8% range. Of the total mapped about 5% had underlying rock within 5 m of the surface.

Land use

Despite its coarse texture, a few areas of this marginal soil are being cultivated. Its best use is grazing despite a relatively low carrying capacity. It is not suitable for irrigation because of its low water holding capacity. This unit has potential as a possible source of gravel.

2.6.38 PEMUKAN (PUN) SOILS

General setting and description

Although some Pemukan soils occur just west of Coutts, the majority are found along the Milk River east of Milk River town. These soils which have developed on a gravelly fluvial material (Fig. 36), are usually associated with ridged and terraced landforms along the river. The total extent of these well drained soils is slightly in excess of 600 ha.

Pemukan is classified as an Orthic Brown Chernozemic soil. The brown A horizon, about 10 cm thick, has a coarse sandy loam texture and a weak blocky structure. Colors change to dark brown in the B horizon, which has a weak prismatic structure and a coarse sandy loam texture. Usually the lime horizon occurs at the 25 to 30 cm depth, in material which has a pale brown color and a coarse sandy loam to loamy sand texture. Coarse fragments (or gravel) are present in all horizons - about 5% by volume in the A horizon, 10% in the B horizon, and gradually increases with depth to a majority of gravel below the 50 cm depth. Generally pH values are in the neutral range in the A and B horizons, and alkaline below.

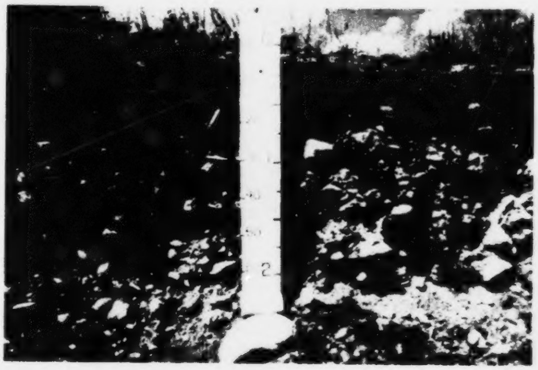


Fig. 36. A Pemukan soil profile

Pemukan map units

PUN1 - Pemukan, the dominant soil amounts to about 60% of the map unit. The remainder consists primarily of other Chernozemic soils, which have developed on a veneer of non-gravelly, sandy loam and loam, fluvial material overlying outwash gravels.

The greater concentration of this unit is towards the eastern side of the county where it occurs on both upper and lower level terraces along the Milk River. The upper terraces are those above the rough broken river banks while the lower terraces are those within the river valley. The majority of this unit, which occurs on slopes in the 3 to 8% range, has underlying bedrock within 5 m of the surface.

Land use

The main limitation of this unit is its low water holding capacity. This, coupled with the low rainfall in the region, makes the Pemukan unit suitable for grazing only, despite a low carrying capacity. It is unsuitable for both dryland and irrigated grain production. It does, however, have potential as a source of gravel.

2.6.39 PURESCAPE (PUR) SOILS

General setting and description

Nearly half the soils in the Milk River Upland have been mapped as Purescape (Fig. 37). They total about 40,000 ha, almost 9% of the total county area. These well drained, dark brown soils have developed in a moderately fine textured till. Surface landform is primarily hummocky with some locations being both inclined and dissected. Slopes are generally greater than 5% over most of the Purescape area. These soils generally occur at elevations between 1070 and 1220 m.

Purescape is classified an an Orthic Dark Brown Chernozemic soil. The A horizon, about 12 cm thick, has a dark grayish brown color and a loam to clay loam texture. Often the Ah horizon tongues or wedges into the B horizon, in some locations up to 12 to 15 cm. The B horizon is dark brown in color, has a clay loam texture and a distinct prismatic structure. A brown to pale brown Cca horizon usually occurs at 40 cm below the surface. Neutral pH values in the upper profile change to moderately alkaline in the lime horizon and below. A detailed description of a Purescape profile is included in the Appendix.

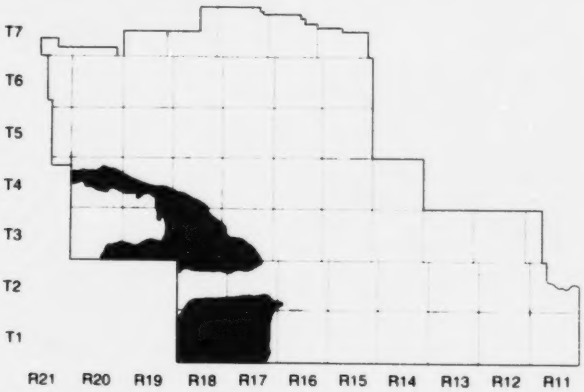


Fig. 37. Distribution of Purescape soils.

Purescape map units

PUR1- In this unit, Purescape is the dominant soil occupying up to 90% of the unit. Inclusions of a few other soils may also occur. On steeper south facing slopes a Rego Dark Brown Chernozemic soil (WID) may occur. On the more moist north facing slopes an Orthic Black Chernozemic soil (BZR) may be found. In some locations where ice-contact material is present, the Rockford profile may occur. A few sloughs or Gleysolic soils may also be present in this unit.

About 18% of the Purescape soils are included in this unit. Four topographic phases were recognized:

(a) PUR1/4 with slopes in the 6 to 9% range; covers about 3100 ha.
(b) PUR1/4D also with slopes in the 6 to 9% range, but on a dissected landscape; covers about 1600 ha.
(c) PUR1/5 with slopes in the 10 to 15% range; covers about 2000 ha.
(d) PUR1/6D with slopes in the 15 to 30% range on a dissected landscape; covers about 400 ha.

PUR2 - The main characteristic of this unit is the numerous small undrained depressions in which sloughs or Gleysolic soils occur (Plate IF). These depressions account for about 1/4 of the unit area. The well drained upland portions of the unit are composed primarily of the Purescape profile. Minor inclusions similar to those in the PUR1 unit, may also be found.

One topographic phase was mapped (PUR2/5-4) with slopes of 7 to 13%. Its total extent is almost 3700 ha.

PUR4 - This is the most extensive of the Purescape map units occupying about 30% of the Purescape soil area. Main concentrations occur in an area some 10 km southwest of Milk River town, as well as on the slopes leading to the Milk River Upland. This unit is often associated with farming on slopes so steep (over 10%) that cultivation is a questionable practice from a soil conservation point of view.

In this unit, the Purescape profile is dominant occupying up to 70% of the area in units with lower slopes, and as little as 40% in units with steeper slopes. The Rego Chernozemic profile (WID), which ranges in extent from 20 to 50% can be found on the upper and steeper slope positions. Units with more severe topography will usually have up to 20% Orthic Regosol soils.

Four topographic phases were recognized:

(a) PUR4/4 with slopes of 6 to 9%; covers about 3200 ha. Of this about 15% has bedrock within 5 m of the surface.
(b) PUR4/5 with slopes of 10 to 15%; covers about 2700 ha.
(c) PUR4/5D also with slopes of 10 to 15%, but on a dissected landscape; covers about 4200 ha.
(d) PUR4/6D with slopes of 16 to 30% on a dissected landscape; covers about 1500 ha.

PUR6 - In this unit, a variety of fluvial or ice-contact deposits are closely associated with the dominant Purescape profile. These coarser deposits comprise about 1/3 of the map unit. Some locations have a veneer of sandy loam over till (MGR), other have fluvial lacustrine material below a sandy loam veneer (FOR). A few locations have coarse textured till mixed with the normal till. This unit occurs in areas adjacent to the Milk River drainage way.

About 500 ha were mapped all on one topographic phase with slopes in the 6 to 9% range.

PUR7 - This unit contains 20 to 30% content of Solonetzic soils developed on a more saline till. They are primarily the Solodized Solonetz (GRG) and the Solod which occur in almost equal amounts. Eroded pits are a common feature (Fig. 38) where these Solonetzic soils occur. Purescape, the dominant profile, is present in 60 to 80% of the unit.

About 6% of the Purescape soils belong to this unit. It occurs on both sides of the Milk River towards the west side of the county. Bedrock is within 10 m of the surface, compared to the greater depth elsewhere in the Milk River Upland. On the north side of the Milk River this unit has bedrock within 5 m of the surface.

One topographic phase was mapped with slopes in the 3 to 9% range. Of the 2300 ha mapped about 20% has bedrock within 5 m of the surface.

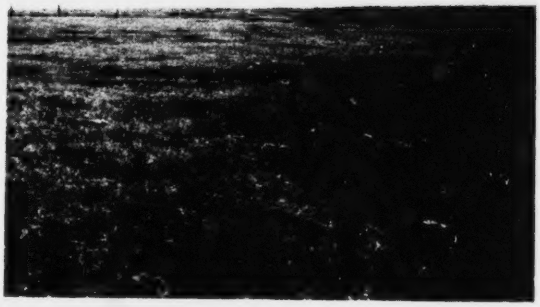


Fig. 38. Eroded pits in PUR7 unit.

PUBZ1 - This unit amounts to nearly 10% of the Purescape soil area. It is found in the western part of the county in the transition area bordering the Black Soil Zone. Some occurs on the northern slopes leading to the Milk River Upland (Fig. 39) where it is generally associated with an inclined and dissected landform. Some occurs within the upland on a hummocky morainal landform.

Purescape, the dominant soil amounts to about 60% of the map unit. About 25% is the Orthic Black Chernozemic soil (BZR) which usually occurs on northern aspects and lower slope positions. In a few lower positions some unusually deep profiles may be found where slopewash has accumulated to form deeper than normal Ah horizons. It is not unusual to find a Rego Chernozemic profile (WID) on the steepest slopes with southern exposures.

Five topographic phases were mapped:

(a) PUBZ1/4 with slopes of 6 to 9%; cover about 500 ha.
(b) PUBZ1/4D also with slopes of 6 to 9%, but on a dissected landscape; covers about 500 ha.
(c) PUBZ1/5 with slopes of 10 to 15%; covers about 500 ha.
(d) PUBZ1/5D also with alopes of 10 to 15%, but on a dissected landscape; covers about 1150 ha.
(e) PUBZ 1/6D with slopes of 15 to 30% on a dissected landscape; covers about 1200 ha.

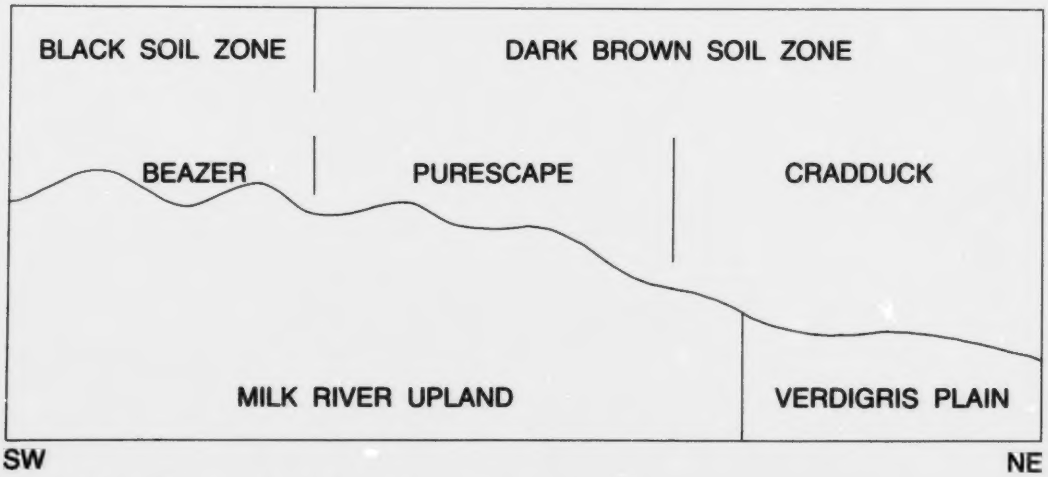


Fig. 39. Schematic cross section of a Beazer-Purescape-Cradduck sequence.

PUBZ2 - About 13% of the Purescape soils belong to this unit. Its occurrence within the Milk River Upland is mainly in the transition area from dark brown to black soils. Associated topography is very hummocky which results in the 15 to 30% content of undrained depressions in which sloughs are common (Plate IF). Soil components are similar in amount and landscape positions to those described in the PUBZ1 unit.

Two topographic phases were mapped:

(a) PUBZ2/4 with slopes of 6 to 9%; covers about 400 ha.
(b) PUBZ2/5 with slopes of 10 to 16%; covers about 4700 ha.

PULU1 - This unit was mapped within the Milk River Plain in areas where till has been overlain by a veneer of silty lacustrine material. The unit occurs on undulating to hummocky landscapes between the Milk River and the rougher uplands some distance from the river. Purescape, the dominant profile can be found on the higher landscape positions. Between the highs where slopes are smoother, the Lupen profile can be found. It occupies about 30% of the unit. Small areas of steeper topography, may have minor inclusions of Rego Chernozemic profiles (WID).

One topographic phase was mapped (PULU1/3-4) with slopes of 3 to 8%. Its total extent is more than 1700 ha of which about 10% has bedrock within 5 m of the surface.

PULU7 - Although this unit occurs in the same general area, and has similar parent material relationships to that of the PULU1 unit, its surface features are quite different. Not only is the topography smoother but it is dissected by shallow channels leading towards the Milk River. Another surface feature is the eroded pits which dot the landscape. These pits are associated with the Solonetzic soils which form about 1/3 of the unit. Most prevalent of these Solonetzic soils are the Solodized Solonetz (GRG or KHO) and the Solod. The major soils are still Purescape and Lupen which occur in amounts similar to those in the PULU1 unit.

One topographic phase was mapped (PULU7/3D) with slopes of 2 to 5% on a dissected landscape. It totals about 1700 ha of which nearly 20% has bedrock within 5 m of the surface.

PURF2 - This unit occurs in the northern part of the Milk River Upland in an area where soils are transitional between dark brown and black. There it occurs on a hummocky morainal landform mixed with ill defined ice contact features. About 25% of the unit has developed on gravelly materials (RFD soils).

A very important feature of this unit is the significant amount of undrained depressions caused by the hummocky landform. These depressions have Gleysolic soils and many contain water well into the summer season. Surface stones are a common feature of this unit especially where the ice-contact material is prevalent.

Total extent of this unit is about 2100 ha all on one topographic phase (PURF2/6) with slopes in the 16 to 30% range.

Land use

Presently, most of the Purescape soils are being grazed which is undoubtedly their best use since most of them occur on rough topography. However, the Purescape soils in the area 10 to 12 km south west of Milk River town are being cultivated even though they are on steep slopes. As a result, considerable erosion has taken place which is reflected in the greater amount of PUR4 units mapped in that area.

Most Purescape soils have no inherent soil characteristics which limit their capability for dryland agriculture. However, a frost free period (about 90 days) does impose a climatic limitation. Generally, the units with minor topographic limitations are considered to be fairly good for dryland agriculture.

Because of their rough topography most Purescape map units are non irrigable. Some units on better topography are non irrigable because of other limitations such as those with Solonetzic soils ("7" units), and those with numerous undrained depressions ("2" units). Thus only about 20% of the Purescape soils are potentially irrigable.

As already stated Purescape areas are most suitable for grazing. The many units with undrained depressions ("2" units) offer an additional grazing advantage as they serve as a source of stock water for a large part of the grazing season.

2.6.40 RAMILLIES (RAM) SOILS

General setting and description

Ramillies soils consist of a veneer of medium textured fluvial material overlying gravel (Fig. 40). They occur on upper level terraces along the banks of both Chin and Etzikom coulees. Total extent of these well drained soils is slightly less than 800 ha.

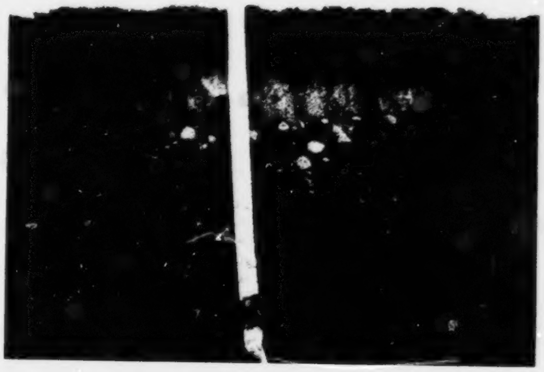


Fig. 40. A Ramillies soil profile.

Ramillies is classified as an Orthic Brown Chernozemic soil. The Ah horizon, about 10 to 12 cm thick, has a brown color, a weak granular structure, and a sandy loam to loam texture. There is a gradual change to the dark yellowish brown Bm horizon which has a weak prismatic structure, and a loam to heavy loam texture. A lime horizon is usually encountered around the 35 cm depth. In most Ramillies profiles there is an abrupt change to the underlying coarse material, which usually has a high gravel content. A neutral reaction is common in the A and B horizons, while horizons below are alkaline.

Ramillies map units

RAM1 - This is the only Ramillies unit that was mapped. In addition to the dominantly Ramillies profile, other Chernozemic soils are present related to the depth of finer material overlying the gravel. These can range from less than 20 cm (PUN) to over 1 m (CHN) each of which may occupy up to 20% of the unit. Of these various soils only Pemukan seems to relate to surface features. Its expected occurrence is either on slight ridges or at the edge of "miniterraces" within the major terrace unit.

Only one topographic phase was recognized (RAM 1/3:R) with slopes of 2 to 5%. The entire unit has underlying bedrock within 5 m of the surface.

Land use

Ramillies soils are marginal for dryland agriculture, primarily because of their low water holding capacity coupled with the low precipitation levels in that region. These factors also result in a low grazing carrying capacity. For irrigation this soil has only a fair irrigation rating because of the underlying gravel, as well as the relatively shallow depth to bedrock. Ramillies units are a possible source of gravel.

2.6.41 ROUGH BROKEN (RB) MAP UNITS

These units, occurring throughout Warner County, total almost 30 000 ha. They are the undifferentiated steep lands that form the banks to stream channels and spillways. Formed during the immediate post glacial period of most active stream erosion, most are now quite stable and grass cover has become established. Nevertheless some downslope creep is evident on steeper slopes, as is water erosion. These slope processes are sufficient to interfere with soil formation to the extent that soils in these map units are dominantly Rego Chernozemic and Regosolic soils. Slopes are extremely variable but always exceed 10%. Four units have been established. Three occur along both sides of wide valleys and are separated by the extent of rock outcrops. The fourth unit is used along modern erosional channels which have narrow valley bottoms.

RB1 - This unit, which includes almost 40% of all rough broken areas, has less than 10% bedrock exposures. Rego Chernozemic soils are dominant with about 30% Regosolic soils. With some exceptions most of the RB units associated with the several spillways in Warner County have been mapped as RB1 (Fig. 41). The banks of the Milk River, upstream from its junction with Verdigris Coulee, are also RB1.

Fig. 41. RB1 along coulee. Note salinity in foreground.

RB2 - There is about half as much of this unit as there is of the RB1 unit. Exposed bedrock (which is its main identifying feature) is up to 60% . With this increased bedrock there is an increased amount of Lithic phases of both the Rego Chernozemic and Regosolic soils, which are generally found in similar proportions to that in the RB1 unit. This unit forms the banks of several coulees especially Chin, Kipp, Verdigris and Etzikom coulees as well as portions of the Milk River banks downstream from Verdigris Coulee.

RB3 - Bedrock exposures are greater than 60% in this unit. However the soils are similar to those in the previous two units and are in similar proportions. About 6% of the RB units have been mapped as RB3 mainly along the Milk River in the vicinity of Writing-On-Stone Provincial Park (Plate I-C). Minor amounts of this unit also occur immediately south of Milk River Reservoir.

RB4 - This unit, totalling about 11000 ha is found throughout the county. It includes the rough broken banks which form the V shaped valleys or gullys associated with modern erosional channels and smaller streams (Fig. 42). They are very noticeable as long erosional fingers dissecting the "foothills" area below the Milk River Ridge. Similarly they are a striking landscape feature connecting the Sweetgrass Upland and Milk River.

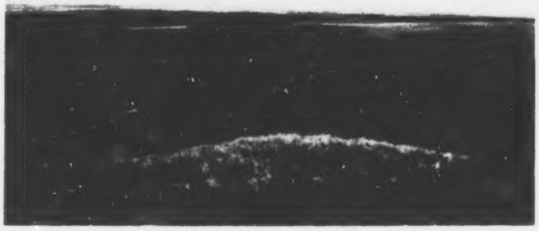


Fig. 42. An RB4 unit in foreground.

Land use

All RB units are considered non arable. RB4 units in particular are a nuisance to farming operations as they often cut up and dissect land which might otherwise be cultivated. Areas which have a high proportion of RB units are often fenced off and used for grazing. The carrying capacity varies inversely with the amount of bedrock exposed.

2.6.42 READYMADE (RDM) SOILS

General setting and description

These soils occur in the western part of Chin Plain north and east of Stirling (Fig. 43), where they total about 5000 ha. Soil development has taken place on a weakly saline till similar to that on which Maleb soils have developed. The dominant associated landform is a hummocky moraine.

Classified as an Orthic Dark Brown Chernozemic soil, Readymade has a dark grayish brown A horizon from 12 to 15 cm thick. It has a loam to silt loam texture and a loose granular structure. The dark brown B horizon, about 30 cm thick, has a weak prismatic structure and loam to heavy loam textures. A moderately calcareous lime horizon usually occurs near the 45 cm depth in a clay loam material. Neutral to mildly alkaline conditions in the upper profile increase to moderately alkaline in the lime horizon and below. A few stones and coarse fragments can be found throughout the profile.

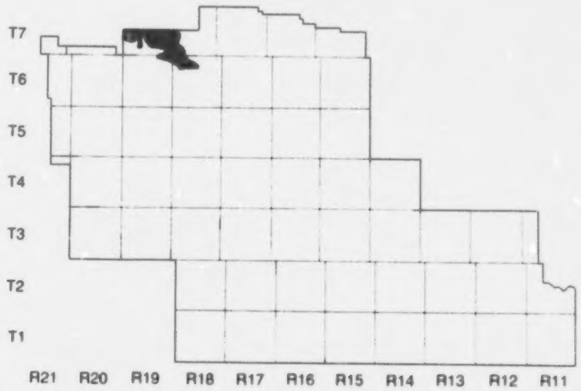


Fig. 43. Distribution of Readymade soils.

Readymade map units

RDM2 - This unit occurs on a continuation of the hummocky morainal landform associated with the MAB2 unit, which extends into the Dark Brown Soil Zone. Like the MAB2 unit, up to 30% of the unit consists of undrained depressions in which sloughs or Gleysolic soils occur. Readymade, the dominant soil occurs in about 60% of the unit on the well drained portions of the landscape. Some variation in profile thickness is common, and water deposited veneers may occur on the lower landscape positions.

One topographic phase was mapped (RDM2/4) with slopes in the 6 to 9% range. Total extent is in excess of 1400 ha.

RDM4 - This unit is differentiated by the 20 to 30% content of Rego Chernozemic soils. These thin profiles occur on the crowns of steeper slopes with the hummocky unit. The Readymade profile which is dominant is found on the topographic positions with less severe slopes. Inclusions of lacustrine veneers (WNY) as well as some of gleyed variants may also occur, particularly on the hummocky units.

One topograhic phase (RDM4/4) was recognized with slopes of 6 to 9% and a total extent of nearly 800 ha.

RDWN1 - Along with the 50 to 70% content of Readymade soil, this unit has a 20 to 40% content of a veneer of medium textured lacustrine material over the till (WNY). Minor amounts of Gleysolic soils are sometimes present in this unit.

One topographic phase (RDWN1/3) was recognized, totalling nearly 2800 ha, all with slopes of 2 to 5%.

Land use

Most Readymade soils are presently being cultivated under a dryland farming system. They are generally considered to be fairly good arable soils with no major limitation other than limited precipitation. Some reduced productivity can, however be expected on the RDM4 unit because of the presence of the less fertile Rego profiles.

Readymade units are considered to have good irrigation potential, except for the RDM2 unit which is rated non irrigable primarily because of the limitations imposed by the numerous undrained depressions.

All Readymade units have a relatively high grazing capability, especially where undrained depressions are present.

2.6.43 ROCKFORD (RFD) SOILS

General setting and description

These soils occur only in the Milk River Upland in the southwest portion of the county (Fig. 44) where they occupy about 2400 ha. Rockford soils are well drained, black, grassland soils which have developed on a gravelly and stony ice-contact material. Landscape features are generally hummocky with some ridged tendencies and slopes in the 6 to 20% range. These soils occur mainly around the perimeter of the basin like area centred at the west side of Township 3, Range 19. Vegetation is predominantly a mixed grass prairie composed of fescue and numerous herbs and small shrubs.

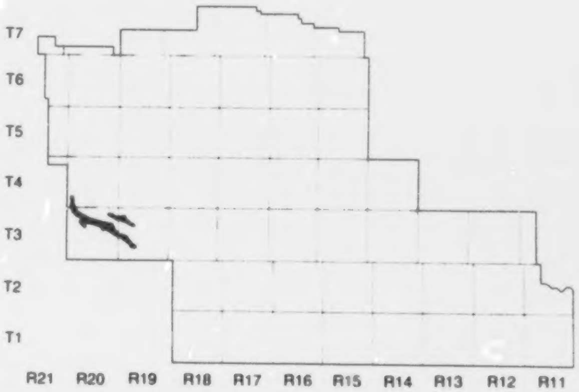


Fig. 44. Distribution of Rockford soils.

The most noticeable feature of this soil is the gravel and stones that are present throughout the profile. Coarse fragment content is variable, ranging from 10 to 40% by volume in any one horizon. Consequently, surface stoniness is also variable, ranging from locations which are extremely stony to locations where very few surface stones appear.

Rockford soils are classified as Black Chernozemic soils. They have an A horizon, about 10 cm thick, which has a very dark grayish brown color and a loam to sandy loam texture. The B horizon usually up to 30 cm thick, is dark brown in color and has a loam texture. This horizon is further characterized by a weak prismatic structure and a slightly hard consistency. A moderately calcareous lime horizon occurs at the 45 to 50 cm depth in sandy loam materials. A clay loam till of low stone content underlies the Rockford soil at depths usually exceeding 1 m. Included in the Appendix is a more detailed description of a Rockford soil.

Rockford map units

RFBZ1 - About 15% (400 ha) of the Rockford soils are comprised of this unit. It has a 40 to 60% RFD component in combination with 20 to 40% till soils (BZR). Small amounts of coarser ice-contact materials (KNT) may be found as well as gleyed variants. Generally, this map unit occurs adjacent to units which are composed of dominantly BZR soils. This map unit was mapped only on Class 4 topography.

RFKN1 - This is the most frequently occurring unit, accounting for about 70% (1800 ha) of the Rockford soil areas. It occurs primarily on the side slopes of the basin previously mentioned. Soils are dominantly Rockford, up to 70%, with 20 to 40% of the unit being made up of sandy ice-contact materials (KNT). Small amounts of till (BZR) and lacustrine (SOF) as well as gleyed variants may occur in widely separated locations. It was mapped on Class 5 topography only.

RFKN2 - This unit contains the same soils as RFKN1, and in similar amounts. It differs, however in having from 20% to 30% poorly drained areas in which Gleysolic and gleyed soils occur. This difference can be attributed to the fact that this unit is located primarily in the valley bottom where surface ponding is more likely to occur. The unit occurs only on Class 4 topography.

Land use

Almost all the Rockford soil areas are being grazed. Although some cultivation is being carried out on the RFBZ1/4 unit. The predominance of rough topography, as well as the occurrence of surface stones are the main limitations to both dryland and irrigated agriculture. Thus, Rockford soils are best suited for grazing, for which purpose they have a relatively high carrying capacity. Rockford soil areas have some potential as a source of low quality gravel.

2.6.44 SALINE (S) SOILS

These include the undifferentiated saline areas which were large enough to outline on the soils map, generally greater than 5 ha in size, and identified by the map symbol S. Also included are saline areas smaller than 5 ha (Fig. 45) which could not be outlined and were identified by the spot symbol S on the soils map. This latter group were very numerous. During the field survey about 400 saline spots were observed and noted along the lines of traverse.

Fig. 45. A saline spot less than 5 ha in size.

About 1400 ha of S areas and spots were mapped. This assumes an average size of about 2.5 ha for each S spot. These areas occur primarily in Etzikom and Verdigris plain. (Total extent of salinity is covered in the salinity section).

Land Use

These soils have little agricultural value in their present state. They are so saline that they are either devoid of vegetation or are covered with salt tolerant species such as kochia.

2.6.45 SLOUGHAY (SLY) SOILS

General setting and description

This poorly drained soil has developed on clayey lacustrine material on level to depressional topography. Although it does occur on Verdigris Plain, its main occurrence is in Chin Plain primarily within the Brown Soil Zone. Its total extent is about 1200 ha.

Sloughay has been classified as a Rego Humic Gleysol. It has about 10 cm of grayish colored Ah, which has a silty clay texture. The underlying C horizon, which is very uniform, also has a silty clay texture and is dark gray in color. A low to medium lime content further characterizes the C horizon. A detailed description of a sloughay profile is included in the Appendix.

Sloughay map units

SLY1 - The Sloughay map unit is very uniform being almost entirely composed of the Rego Humic Gleysol (SLY). It may have up to 10% Orthic Humic Gleysol as well as some water in lower landscape positions. Many of the undifferentiated G units may be composed of Sloughay soils. Slopes of the SLY units do not exceed 2%.

Land use

Wetness and poor soil drainage preclude both dryland and irrigated annual crop production on this unit. Despite these limitations some areas have been used for grain production during periods of below normal precipitation. The unit is best suited for perennial forage crop production or for grazing purposes as it has a high carrying capacity.

2.6.46 STANDOFF (SOF) SOILS

General setting and description

Only a limited amount (500 ha) of Standoff soils were mapped in Warner County, all on the sloping landforms associated with the broad valley found in Township 3, Range 19 (Fig. 20). These black grassland soils have developed on moderately fine to medium textured, stone free, lacustrine materials.

Standoff is classified as an Orthic Black Chernozemic soil. It has a very dark grayish brown, loam to silt loam A horizon, about 15 cm thick. Below it, the prismatic structured B horizon is dark brown in color, and generally has a loam to clay loam texture. With depth, colors become lighter and structure becomes less obvious. Moderate concentrations of lime start at about the 30 cm depth. At the lower depths silt loam to clay loam textures are most common, although in some locations coarser subsoil textures may be found.

Standoff map units SOF1 - This is the only Standoff unit mapped. It is a relatively pure unit, containing about 80% Standoff soils. Small amounts of soil developed on sandy fluvial material (KNT) may occur within this unit. Towards the upland side of the area, till is often encountered within 1 m of the surface. Gleyed variants may be found in a few isolated locations where surface drainage has been impeded. Only one topographic phase was mapped with slopes ranging from 3 to 8%.

Land use

A large portion of this unit is being used for forage production, mainly alfalfa. Although the unit has no soil limitations for crop production, its location in the Milk River Upland places a climatic limit on field crop production. The short frost-free period (less than 90 days) allows only coarse grains to be grown under either dryland or irrigated conditions. For grazing purposes, this unit has a high carrying capacity requiring less than 10 ha per animal unit year.

2.6.47 SPROLE(SOL) SOILS

General setting and description

These soils were mapped on the northern slopes of the Sweetgrass Upland (Fig. 46), in the southeastern part of the county generally above the 1070 m elevation. There, they total nearly 3000 ha on a hummocky, dissected and inclined morainal landform (Fig. 7).

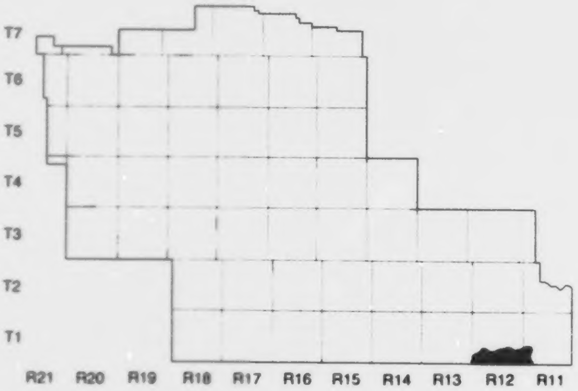


Fig. 46. Distribution of Sprole soils.

Sprole is clasified as an Orthic Dark Brown Chernozemic soil. It has a 12 to 15 cm thick Ah horizon which has a dark grayish brown color, a loam to clay loam texture, and a fine granular structure. The dark brown B horizon is 15 to 20 cm thick, has a strong subangular blocky structure and a clay texture. Below it, the dark yellowish brown lime horizon occurs at or near the 50 cm depth. It also has a clay loam texture which remains fairly constant with depth. Coarse fragments which are less than 5% in the upper profile usually increase in the subsoil. Neutral to mildly alkaline pH values at the surface increase to moderately alkaline in the lower profile.

Sprole map units

SOL1 - This is the only unit mapped on the Sweetgrass Upland. Sprole, the dominant soil occupies up to 70% of the unit. Some Rego Chernozemic profiles occur on the steeper slopes. Most of the unit has a dissected landscape more evident towards the southern part of the area. In some locations inclusions of stony phases can be found. On better topographic positions some undrained depressions may occur in which gleyed variants or Gleysolic soils are present.

Three topographic phases were recognized:

(a) SOL1/4 with slopes of 6 to 9%; covers a little more than 900 ha.
(b) SOL1/5D with dissected slopes of 10 to 15%; covers a little more than 1100 ha.
(c) SOL1/6D with dissected slopes of 16 to 30%; covers about 800 ha.

Land use

Because of the rough topography most Sprole soils are best suited to grazing, for which use they have a relatively high rating. Only the SOL 1/4 unit has potential for cultivated agriculture. It is rated as fairly good for dryland agriculture and good for irrigated agriculture.

2.6.48 SEVEN PERSONS (SPS) SOILS

General setting and description

These soils have developed on a moderately fine to fine textured, stone free lacustrine material deposited on a level to gently undulating landscape. Their extent is limited in Warner County, occurring on no more than 340 ha. They can be found in elongated areas in lacustrine infilled drainage channels, all within Verdigris Plain.

Seven Persons is clasified as an Orthic Brown Chernozemic soil. It has a grayish brown Ah horizon, about 10 cm thick, which has a granular structure and a silty clay loam texture. The B horizon has a dark grayish brown color and a silty clay loam to silty clay texture. This horizon, about 25 cm thick, is further characterized by a blocky to irregular prismatic structure. A lime horizon usually occurs at about the 35 cm depth, in an olive brown silty clay loam material. Materials of similar texture continue to the 1 m depth and below. A neutral to mildly alkaline reaction prevails in the upper profile, changing to moderately alkaline in the lower profile.

Seven Persons map units

SPS3 - Only one unit was mapped. In this unit, about 60% is occupied by the Seven Persons profile. The remainder is mainly Lilydale, the salinized phase of the major Chernozemic soil. The unit also contains small amounts of Solonetz (PTA) and Solod (RMR), both developed on lacustrine materials. These two Solonetzic soils occur indiscriminately in the unit.

One topographic phase was recognized (SPS3/2), all on slopes less than 2%.

Land use

The limiting effect of low rainfall is somewhat offset by the high moisture holding capacity of Seven Persons soils. Further limiting its potential is the presence of salinity which results in it being considered as non irrigable. For grazing this unit has a fair rating.

2.6.49 SEXTON (SXT) SOILS

General setting and description

Sexton soils occur mainly within Kipp and Middle coulees which lie within Verdigris Plain. These well drained soils, totalling 2440 ha, have formed on the fluvial aprons associated with the spillway valleys.

These soils, classified as Humic Regosols, are equally divided between the Orthic Humic Regosol and the Cumulic Humic Regosol. Both have a weakly developed Ah horizon from 10 to 20 cm thick. This horizon has a very dark grayish brown color, a sandy loam texture, and a weak granular structure. In the Orthic profile the material below the A horizon, is generally pale brown in a structureless sandy loam material. The Cumulic profile has similar textures but has buried Ah horizons at various depths. These buried horizons are dark grayish brown to brown in color with pale brown material between. The buried horizons are variable both in number and thickness, ranging from 1 to 4 or 5 in number, and from 1 to 20 cm in thickness, all within the first metre of material. Weakly calcareous conditions prevail in all Sexton soils. A detailed description of a Cumulic Humic Regosol can be found in the Appendix.

Sexton map units

SXT1 - Slightly more than 600 ha of this unit was mapped in the county. It is found in portions of Kipp Coulee as well as in the valley of Red Creek. Some also occurs in smaller coulees northwest of Coutts. In this unit, there is slightly more of the Orthic Humic Regosol than of the Cumulic Humic Regosol. Usually up to 15% of the map unit has weakly developed Chernozemic soils. All SXT1 map units occur on slopes ranging from 1 to 5%.

SXT3 - This unit was mapped on about 1800 ha, the majority of which occurs in Middle and Kipp coulees with lesser amounts in the valley of Red Creek. A small amount has also been mapped in Black Coulee.

The most dominant feature of this unit is the presence of saline phases of the Orthic and Cumulic Regosols, which totals about 30 to 40% of the unit. The non saline component has more or less equal amounts of the two Regosolic soils. Chernozemic soils may also occur, some of which may be salinized. Only one topographic phase of this unit was mapped, on slopes ranging from 1 to 5%.

Land use

SXT1 soils have a low water holding capacity and a relatively low natural fertility, factors which result in a marginal rating for dryland agriculture. Similarly, these characteristics result in a fair irrigation rating and a relatively low grazing carrying capacity. The saline characteristics of the SXT3 unit is a further limitation resulting in a capability rating of Class 5 for agriculture, and a non irrigable rating. Its grazing carrying capacity would also be less than that of the SXT1 unit.

2.6.50 TEMPEST (TEP) SOILS

General setting and description

Almost 800 ha of Tempest soil was mapped in Warner County mainly within the Brown Soil zone, and about equally distributed within Chin Plain and Verdigris Plain. It occurs in poorly drained level to depressional areas where lacustrine materials have been deposited.

These soils have been classified as Humic Luvic Gleysols. They have grayish Ah horizon at least 10 cm thick, and a distinct Ae horizon, both with loamy textures. The B horizon is much finer textured and darker colored than the A horizon. In the lower portions of the profile textures are generally silty clay loam. There is strong evidence of poor drainage in the entire profile particularly in the lower A and upper B horizons where distinct reddish colored mottles appear. Lime, if present, is of low concentration and then only in the lower part of the profile.

Tempest map units

TEP1 - The majority of the unit contains the Tempest soil and up to 20% of the Orthic Luvic Gleysol, which also has an Ae horizon but a thin Ah horizon. Water bodies may also occur in the unit. Slopes in the Tempest map unit are all less than 2%.

Land use

Although some Tempest areas have been used for annual crop production during dry years, their best use probably is perennial forage crop production or grazing as they have a high carrying capacity.

2.6.51 VAN CLEEVE (VAC) SOILS

General setting and description

Van Cleeve soils are well drained, and have developed on a mixture of morainal and fluvial materials. They are associated with the beginning of some of the spillways (Fig. 47), where they occur either within the spillway or on terraces along the spillway sides. These areas are probably the result of water erosion or scouring to bedrock, leaving behind a veneer or blanket of coarser morainal and fluvial material, and numerous large stones. Bedrock exposures are a common feature, hence there is often a ridged landform associated with a terraced landscape, all of which is bedrock controlled. These soils which total about 1800 ha are primarily associated with Etzikom and Middle coulees.

Although Van Cleeve soils are classified as Orthic Brown and Dark Brown Chernozemic soils their development is weak. Textures may be quite variable but are most often sandy loam. Grayish brown colors prevail in materials which are moderately calcareous. Depth to underlying bedrock is generally less than 1 m.

Van Cleeve map units

VAC4 - About two-thirds of the Van Cleeve soils in Warner County belong to this unit. Their occurrence is concentrated in an area south and west of Judson where Etzikom Coulee starts. These soils are located more on the terraces and higher levels of the coulee sides than in the valley bottom. This unit occurs where underlying bedrock is dominantly sandstone rather than the shales. The soils are mainly Orthic Chernozemic with up to 40% of the Rego Chernozemic soils. Ridges are a common feature of the landscape, where bedrock is closer to the surface and often exposed. Stones and boulders embedded in the surface are common in this unit.

VAC7 - This unit occupies about one-third of the Van Cleeve soil areas. Most of it occurs at the beginning of Etzikom Coulee, about midway between Stirling and Judson. Lesser amounts were mapped on the south side of Milk River Reservoir near its east end. Underlying bedrock is dominantly of the shaly variety which seems to influence development of a Solonetzic soil. Thus, the unit has from 20 to 40% of a variety of Solonetzic soils in combination with the dominant Chernozemic soils. Solodized Solonetz and Solod seem to be most common with lesser amounts of Solonetz and Solonetzic Chernozemic soils. However, in all instances development of Solonetzic characteristics is relatively weak and indistinct.

Land use

Van Cleeve soils have many characteristics which rule them out for arable dryland or irrigated agriculture. Foremost among these limitations are the proximity to bedrock, surface stones, low natural fertility, low water holding capacity, and the Solonetzic characteristics of the VAC7 unit. These characteristics also lower the grazing carrying capacity to a relatively low level.

Verburg map units

VEB1 - About 60 to 70% of the soils in this unit are Verburg. They occur on the upper and mid slope positions where erosion has removed much of the surface soil. Orthic soils (CRD), which can be found on the mid to lower slopes, occupy about 25% of the unit. The lower slopes often have a deeper than normal profile because of the accumulated slopewash materials. This unit usually has about 10% of more severely eroded slopes where an Orthic Regosol profile can be found.

One topographic phase was mapped (VEB1/5) with slopes in the 10 to 15% range. Of this about 1000 ha had underlying bedrock within 5 m of the surface.

Land use

A large proportion of the Verburg soils are presently being cultivated, despite their associated steep slopes. As a result water erosion continues to be a problem. To stem this kind of soil degradation, these soils should be put into forage production or grazing, which is their best use, even though their carrying capacity is not that high. The steep slopes rule out irrigation entirely.

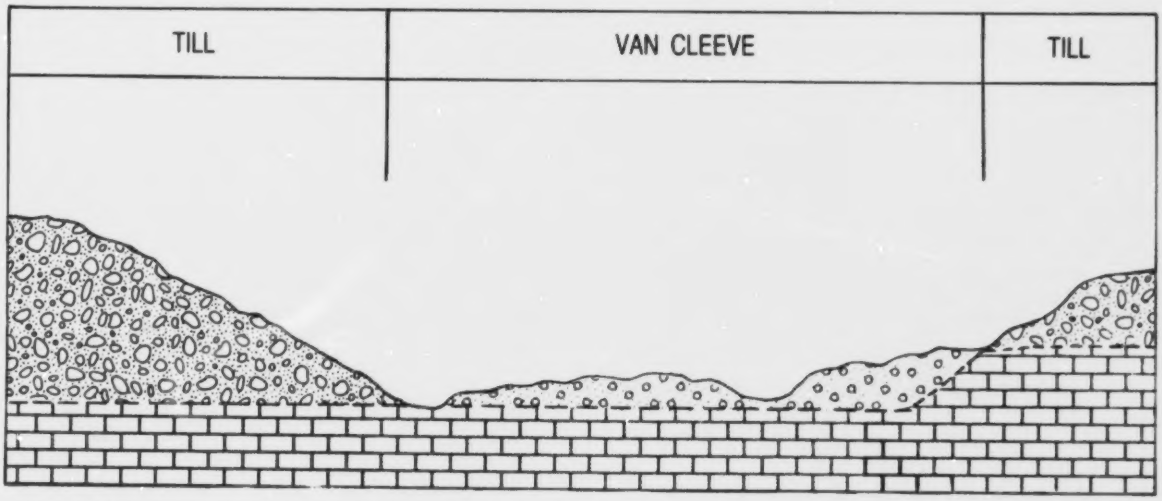


Fig. 47. Schematic cross section of a Van Cleeve soil area.

2.6.52 VERBURG (VEB) SOILS

General setting and description

Verburg soils have developed on a medium to moderately fine textured till. They occur mainly on the lower slopes leading to the Milk River Ridge and have landform characteristics which are hummocky as well as inclined and sometimes ridged. This soil can also be found on some of the less steep banks along both Kipp and Middle coulees. Total extent of Verburg soils is slightly in excess of 1600 ha.

Verburg, classified as Rego Dark Brown Chernozemic soil, is usually calcareous to the surface. The A horizon, in most instances an Ap horizon, is 12 to 15 cm thick. It has a loam to clay loam texture and a dark grayish brown color, a reflection of the lime which cultivation has incorporated from below. Occurring immediately below the cultivation layer (Ap), the lime horizon is brown to pale brown in color and has a clay loam texture. A very weak granular structure in the A horizon gives way to a structureless subsoil. Mildly alkaline pH values at the surface change to moderately alkaline in the lime horizon and below.

2.6.53 VICTOR (VTR) SOILS

General setting and description

These soils have developed on a moderately saline, stone free lacustrine material with a gently undulating surface form. They are most evident in a fairly narrow band along the base of the Milk River Ridge west of Warner. There, they are associated with a variety of lacustrine soils all influenced to some degree by salinity. Some Victor soils also occur within Kipp Coulee at its eastern extreme just west of the town of New Dayton. Total extent of Victor soils is just over 700 ha.

Victor is classified as a Dark Brown Solonetz. It can be recognized by the thin Ah over an abrupt boundary to the solonetzic B horizon. The A horizon, about 5 cm thick, has a granular structure and a silty clay loam texture, and is dark grayish brown in color. The coarse blocky Bnt horizon is very hard, has a very dark gray color and a silty clay texture. Lime and salts usually occur at, or just below the 30 cm depth, in a silty clay loam material which is dark gray in color. Values for pH are neutral to mildly alkaline in the A horizon, moderately alkaline in the B horizon, and moderately to strongly alkaline in the subsoil.

Victor map units

VTR3 - The important feature of this unit is the presence of saline soils, mainly Saline Regosols, which make up about 30% of the unit. Victor, the dominant soil occupies about 60% of the unit area. Very minor amounts of Chernozemic as well as other Solonetzic soils may also be found.

One topographic phase was recognized (VTR3/2-3) with slopes ranging from 1 to 4%. Of this about one half had bedrock within 5 m of the surface.

Land use

Salinity, coupled with the undesirable Solonetzic structure, makes this unit unsuitable for both arable dryland and irrigated agriculture. Thus, its best use is grazing despite it having a relatively low carrying capacity.

2.6.54 WARDLOW (WDW) SOILS

General setting and description

About 450 ha of Wardlow were mapped in the vicinity of the Lucky Strike area. This soil has developed on a stone free, moderately saline lacustrine material with a medium to moderately fine texture. It occurs on a level to gently undulating landscape which is generally somewhat lower than its surroundings.

Wardlow, classified as a Brown Solodized Solonetz, can be recognized by its hard columnar round-topped B horizon. The Ah horizon of about 10 cm over has a greyish brown Ae horizon a few cm thick. The change to the Bnt horizon is very abrupt, with a dark brown color, a clay loam to clay texture and a strongly columnar structure. A pale brown lime horizon occurs near the 35 cm depth in a silty clay loam material. Salts are usually encountered in or below the lime horizon. Neutral pH values are common in the A horizon but change to mildly alkaline in the B horizon and moderately alkaline in the C horizon and below.

Wardlow map units

WDW1 - In this unit, Wardlow is the dominant soil occupying about 70% of the unit area. The Brown Solod (KBD) occurs in about 25% of the unit. In minor portions of the unit, often on slightly higher locations, underlying till may be within 1 m of the surface. Soils in these locations are either Solodized Solonetz (DHS) or Solod (GEM). Occassionally spots of salinity may occur.

One topographic phase (WDW 1/2) was mapped with slopes not exceeding 2%.

Land use

Wardlow soils are considered to be marginal for arable dryland farming. This low rating arises from their Solonetzic characteristics which are also responsible for a poor to fair rating for irrigation. Similarly, these characteristics, when coupled with the regional low precipitation, results in a relatively low grazing carrying capacity. Despite the low rating the Wardlow areas mapped are presently in grain production under dryland conditions.

2.6.55 WILDA (WID) SOILS

General setting and description

These thin soils occur on the Milk River Upland where they total approximately 4000 ha. They have developed on a hummocky morainal landform which in some locations is dissected. They are concentrated in areas of rough topography where years of cultivation and subsequent water erosion has resulted in loss of topsoil (Fig. 48).

Wilda is classified as a Rego Dark Brown Chernozemic soil. The A horizon, about 10 to 12 cm thick, contains a variable amount of lime which cultivation has incorporated from the underlying Cca horizon. Loam to clay loam textures prevail in the dark grayish brown A horizon. The Ck, immediately below the A horizon is pale brown in color and has a clay loam texture which continues well into the subsoil. Structure is very weak to absent in the whole profile. Moderately alkaline conditions prevail in all but the A horizon which is mildly alkaline. A detailed description of a Wilda profile is included in the Appendix.

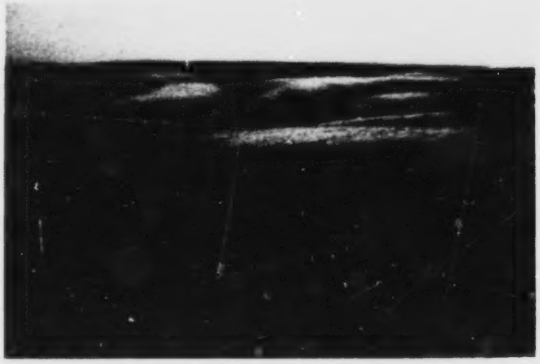


Fig. 48. Erosion on a Wilda soil area.

Wilda map units

WID1 - From 50 to 80% of this unit is composed of the Wilda soil which occurs on the steeper upper and mid slope positions. On the lower slopes which are less steep, the Orthic Chernozemic profile (PUR) prevails which amounts to about 10 to 40% of the unit. The amounts of these two soils varies in proportion to the topographic characteristics - the rougher the topography the higher the amount of Wilda. On the most severe slopes it is not unusual to find an Orthic Regosol soil. The Purescape soils in the trough position often have a deeper than normal profile, a result of accumulated slope wash material eroded from the surrounding higher land within the unit.

Two topographic phases were recognized:

(a) WID1/5 with slopes of 10 to 15%; covers about 3000 ha.
(b) WID1/6D with dissected slopes of 15 to 30%; covers about 1000 ha.

Land use

A significant amount of Wilda soils are being cultivated, despite the limitations imposed by the rough topography. As a result, water erosion is a continuing problem. Wilda map units should, if cultivated, be in forage crop production where annual cultivation is eliminated. The rough topography also rules out irrigation on Wilda map units. They do, however, have a fairly good grazing capability.

2.6.56 WALSH (WLH) SOILS

General setting and description

These are poorly drained clayey lacustrine soils located in broad basins. They occur in isolated areas in both Chin and Verdigris plains for a total of about 600 ha. One area of major concentration lies within the broad drainage way traversed by Highway 36 about 9 km north of Warner. Other areas of Walsh occur in the lacustrine basin in the northwest part of the county.

Walsh, classified as an Orthic Gleysol, has a 2 cm thick A horizon, which is dark grayisn brown in color. This weakly structured and loose material has a silty clay loam texture and a neutral to mildly alkaline reaction. Below this the C horizon has olive gray to dark olive gray colors with brownish colored mottles. This horizon is further characterized by a massive structure and a silty clay texture. Usually there is a low lime content in the C horizon resulting in mildly to moderately alkaline pH values.

Walsh map units

WLH1 - In this unit Walsh is the only soil present. However up to 50% of the unit area may be covered by water particularly in the spring and early summer. This is the situation on the area north of Warner. Later in the season the extent of water decreases to where only a few spots are covered. Common cattail abound in the wetter portions of the unit.

One topographic phase (WLH1/2) was recognized with slopes not exceeding 2%.

Land use

Because of their wet and poorly drained conditions, Walsh soils are unsuitable for both dryland and irrigated agriculture. They are best suited for grazing for which use they have a high carrying capacity, providing water does not cover too much of the unit.

2.6.57 WHITNEY (WNY) SOILS

General setting and description

Whitney soils are quite extensive in the western part of Verdigris Plain (Fig. 49) where they total 9600 ha. They have developed on a veneer of medium to moderately fine textured lacustrine material overlying till (Fig. 22). Surface features are those of a gently undulating to undulating plain.

Whitney is classified as an Orthic Dark Brown Chernozemic soil. It has a granular, dark brown A horizon 10 to 12 cm thick overlying a dark brown prismatic subsoil. A lighter colored, calcareous horizon is normally seen at about 40 cm depth. The till, usually encountered at 50 to 80 cm, has a few stones but the surface loam or silt loam is stone-free.

Whitney map units

WNY1 - This unit accounts for more than 40% of the Whitney soils. Although the major portion occurs in the northwest part of the county, lesser amounts can be found associated with the Milk River in the vicinity of Milk River town. Whitney is the dominant soil occupying about 70% of the unit. In some locations the depth to underlying till may be greater than 1 m (Lethbridge soil). This may occur in about 20% of the unit. Very minor amounts of other soils such as gleyed phases, Rego Chernozemic soils, or soils developed on till where no lacustrine veneer is present may be found.

One topographic phase was mapped (WNY1/2-3) with slopes of 1 to 3%; totalling 4000 ha. Of this 800 ha has bedrock within 5 m of the surface.

WNY3 - The unique characteristic of this unit is the 20 to 40% content of saline soils, of which the majority is Lilydale. Whitney however, is still dominant occupying from 50 to 70% of the area. Gleyed phases, and Gleysols, as well as other Chernozemic soils (LET, CRD) may be present, but in total these inclusions do not exceed 20%.

About 18% of the Whitney soils belong to this unit. Although its occurrence is general throughout the northwestern part of Verdigris Plain, there is a greater concentration in the irrigated areas. One topographic phase was mapped (WNY3/2-3) with slopes of 1 to 3%, totalling 1750 ha. Of this about 800 ha has bedrock within 5 m of the surface.

WNCR3 - This unit also has a 20 to 30% content of saline soils most of which are the salinized phases of the two Chernozemic soils developed on a lacustrine veneer and till materials. It differs from WNY3 in having a significant inclusion of soils developed on till (CRD). Generally, this unit occurs adjacent to till areas.

One topographic phase was mapped (WNCR3/3-2) with slopes of 1 to 4%. Total extent is 3400 ha of which 1700 ha has bedrock within 1 m of the surface.

WNLE1 - This unit recognizes a thicker stone-free surface with about 20 to 40% of the unit having till at depths greater than 1 m (LET soils).

Although minor areas occur elsewhere, this unit is found primarily in an area just northeast of Raymond. One topographic phase was mapped (WNLE1/2-3) with slopes of 1 to 3%. Total extent is about 400 ha.

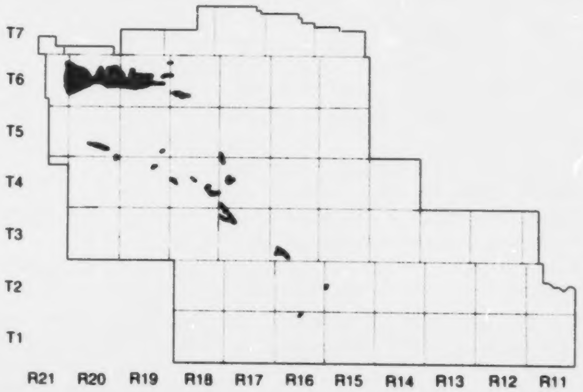


Fig. 49. Distribution of Whitney soils.

Land use

Almost all Whitney soils are being cultivated, primarily for grain production under dryland conditions. Some are successfully irrigated in the Raymond area.

Whitney soils are fairly good for dryland farming with only the limitation of a less than optimum precipitation level. The additional limitation in the saline units results in lower ratings for both dryland agriculture and irrigation. The non saline units are good irrigation areas. They may, however, develop a seepage problem if irrigation water moves laterally along the lacustrine-till interface. Salinity also reduces the carrying capacity of these soils from the relatively high level of the non saline units.

2.6.58 WESTON (WTN) SOILS

General setting and description

These are moderately well to imperfectly drained soils which have developed on clayey lacustrine materials. Most of the Weston soil was mapped on a relatively flat basin-like area between Tyrrell and Weston lakes, into which Middle Coulee empties. Lesser amounts were encountered elsewhere in the county usually associated with minor spillways or drainage channels. A total of 1650 ha were mapped in the county.

Weston soils, classified as Orthic Regosols have no discernible A horizon. Grayish brown surface colors gradually become darker with depth. Although clay to silty clay textures prevail beyond the 1 m depth, the occasional lens of sandy material may occur. Generally, a low concentration of lime is present in material which has a massive structure. Salts are sometimes encountered in the lower parts of the profile.

Weston map units

WTN1 - Less than 300 ha of this unit was mapped most of which occurs in the western part of Black Coulee. In WTN1 units, Orthic Regosols are dominant, but a significant content of Humic Regosols with an Ah horizon, are also present. Both gleyed and saline phases may also occur. Only one topographic phase was recognized on slopes from 2 to 5%.

WTN3 - The majority of the approximately 1400 ha of WTN3 mapped, occurs in the lacustrine area between Tyrrell and Weston lakes. Lesser amounts occur in the valley associated with Macklin Lake about 6 km northwest of Coutts. Orthic Regosols are the dominant soils in the WTN3 unit with an occasional occurrence of Humic Regosol. Saline phases are a significant component, generally ranging from 20 to 30% of the map unit. Saline phases seem to be more prevalent in the southern part of the area between Tyrrell and Weston lakes, while in the northern part gleyed phases seem to increase. This unit is relatively flat with slopes not exceeding 2%, thus it is subject to flooding as runoff and downward percolation of water is slow.

Land use

Weston soils have a low level of natural fertility. Their high clay content coupled with their low organic matter content results in increased difficulty in cultivation. Salinity in the WTN3 unit is an added limitation resulting in this unit being marginal for dryland agriculture and non irrigable. However, the non saline WTN1 unit is considerably better for both of these agricultural uses. Weston soils have a relatively low rating for grazing.

PART 3. LAND USE, INTERPRETATIONS AND DEGRADATION

3.1 PRESENT LAND USE

Warner County is mainly a grain farming area. About two thirds of its area is under cultivation, concentrated mainly on the Chin and Verdigris plains. Grazing and cattle production is concentrated on the Milk River Upland, 65% of which is in native pasture. A significant area in the southeastern part of the county is also in native pasture due to the poor soil and landscape features that exist there. Increased carrying capacities have resulted from improvements in range management and the introduction of improved range species.

Although irrigated crops are important in the Raymond-Stirling area, irrigation is practiced on less than 5% of the county area. Recent increased use of pumps and centre pivot systems has resulted in some irrigation activity in a few small areas far removed from the main centre of irrigation in the Raymond Irrigation District.

According to 1981 census figures (1) 63% of the cropped land is in wheat, mainly spring wheat, 23% is in barley, and the remaining 14% is in hay and various other crops. That same census found that 39% of the total cropland is in summerfallow.

The following sections cover in more detail some of the factors influencing agricultural production in Warner County. Certain sections have been prepared by specialists from the Lethbridge Agriculture Centre. Their expertise and involvement in various aspects of agriculture in southern Alberta is reflected in their prepared sections.

3.2 DRYLAND FARMING IN SOUTHWESTERN ALBERTA*

Dryland farming implies the growing of crops without irrigation in a climate where water is limiting. Southwestern Alberta has a total precipitation of about 400 mm per year which is far below that required for maximum crop yields. Consequently, successful dryland farming requires a strategy for an efficient use of a limited resource. This strategy has evolved from practices brought (with disastrous consequences) by settlers from areas with humid climates and no wind - to farming methods that have led to increasing yields and improved water use efficiency particularly in the last twenty years.

There are a number of technological innovations that serve as milestones in this evolution. These are: the tractor, which enabled quick and timely field operations, the Noble blade and rod-weeder for stubble mulch farming, furrowopening hoe-drills, combine harvesters that ended the removal of straw by binders and threshers, and herbicides, the most important of which are 2,4-D and triallate. Chemical weed control has resulted not only in reduced competition from weeds, but also in better seedbed moisture because fewer cultivations are needed in the spring. To this list should be added the development of hardy winter wheat varieties that on the average yield about 20% more than spring wheats. The yielding ability of spring wheats has also improved somewhat, and currently recommended varieties yield about 17% more than Marquis.

Recent innovations will continue to improve the ability to grow 'more crop per raindrop' and noteworthy here is the pneumatic applicator, which coupled with a cultivator is capable of placing fertilizer at depths where it is sure to be intercepted by roots.

There is considerable room for improving cropping strategies. Most of the improvement will occur by reducing the need for wasteful summerfallow during which 70 to 80% of precipitation evaporates, runs off or penetrates below the root zone and contributes to saline seeps. Long-term studies have shown that with traditional tillage methods, about 60% of the total water stored in the soil during the 21-month fallow period was received during the first 8 months from harvest to April 20. Consequently, means of increasing soil water storage during this non-crop period is important and could be achieved by improved snow trapping through standing stubble followed by reduced or preferably completely eliminated spring tillage. Zero-till farming is most applicable under conditions where crops are frequently 'stubbled-in'.

With improved moisture conservation between harvest and spring seeding, a flexible cropping system could be used more widely than at present. A flexible cropping system would mean growing a crop in years when stored soil water and expected growing season precipitation are sufficient to produce a reasonable yield while fallowing would only be used when soil water and expected precipitation are not sufficient for that need. Wider adoption of this system would require more fertilizer use and perhaps an economic incentive with a less restrictive grain delivery arrangement. This strategy could further be refined by growing crops that sequentially have greater rooting depths in short-term rotations until the depth of removal exceeds recharge during non-crop periods. Spring wheat-winter wheat-fallow rotation follows this logic. Spring wheat uses soil water to a depth of about 1.2 m. Winter wheat seeded into standing spring wheat stubble will trap snow and use available water to a depth of 1.5 to 2.0 m. The land is then fallowed because the probability is low of replenishing water to that depth in one over-winter period.

Most strategies that increase productivity from a unit area of land will lead to improved water use efficiency and most importantly, in the long-term, will prevent soil degradation by maintaining soil organic matter, reducing saline seeps and controlling wind erosion.

3.3 IRRIGATION IN WARNER COUNTY*

Warner County has an irrigation history dating back to the turn of the century. Some of the first irrigation works in southern Alberta delivered water to the Raymond area. Shortly afterward a canal was constructed from the Milk River with the stated purpose of delivering water around the eastern slopes of the Milk River Ridge toward the present day town of Magrath. More recently, efforts have been made to develop Verdigris Lake as an irrigation water source for local irrigation projects above Verdigris Coulee.

Successful irrigation in the semi-arid climate of southern Alberta depends upon a number of factors the most important of which is a reliable source of good quality water. To date, available water supplies have allowed irrigation development on approximately 17,800 ha of land within

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*Prepared by: S. Freyman, Research Scientist, Agriculture Canada, Lethbridge.

*Prepared by: E. Osborne, Soil Specialist, Irrigation Division, Alberta Agriculture, Lethbridge.

Warner County. Proposed water diversion, storage, and delivery system improvement projects, would increase the total potential for development, to approximately 30,000 ha.

The need for quality water and close access to that resource has concentrated present and potential irrigation activity into three areas. These areas are illustrated in Fig. 50 and include:

a) land within the Raymond Irrigation District Jurisdictional Boundary 1981.
b) the proposed St. Mary River Irrigation District Verdigris Coulee Project.
c) present area of irrigation interest and activity along the Milk River.

Significant irrigation development outside of these three areas is very unlikely unless further water resources can be developed.

The three centers of irrigation activity are basically similar with respect to climate, present land use and potential land use under irrigation. However, there is a general trend for climate to become drier from west to east across the county. The average growing season is 120-140 days (-2C); the area receives 1350-1650 heat units (5C) per growing season; and the moisture deficit usually runs between 250-300 mm per year. Crop production under irrigation is mainly cereals and forage. There is potential and interest in specialty crops but marketing is a problem.

The Raymond Irrigation District

The Canadian Northwest Irrigation Company, under the direction of Elliot Galt and C.A. Magrath, with the assitance of the Mormon Church, brought the first irrigation water to Warner County in July of 1900. Water was diverted from the St. Mary River at Kimball and, through a series of constructed and natural canals, brought water to the Raymond area. The purpose of this early irrigation project was to stabilize an agriculture industry in a semi-arid climate, attract settlers, and in turn, supply needed customers for financially troubled railroads (2).

The Raymond Irrigation District (R.I.D.) was established in 1926 under the Irrigation Districts Act. The farmers of the area took control of construction and maintenance of the irrigation project by authority of the Act (7).

The R.I.D grew to occupy approximately 20,600 ha of land, of which nearly 13,000 ha have been serviced for irrigation. Recently an agreement reached between the Raymond, Taber and the St. Mary River Irrigation Districts, expanded the boundaries of the R.I.D. to include over 86,000 ha of land. All but 10,900 ha of land within the new R.I.D. boundaries lies within Warner County (1)*.

Typical crops grown and land use, as a percent of irrigated acreage, are presented in Table 7. The figures show that barley, alfalfa, hard, and soft wheat totalled over 82% of the irrigated crop acreage in the R.I.D. for 1981.

Latest figures show that although there has been a trend toward sprinkler irrigation in the R.I.D., 62% of the assessed acreage is irrigated by surface methods. Side-roll and pivot irrigation systems apply water to 26% and 12% of the assessed land respectively. It is interesting to note that of all the land presently surface irrigated, over 85% has only minimum surface development. Actual area irrigated may vary from 40 to 90% of the assessed acreage depending on amounts of precipitation.

TABLE 7. Irrigated crops in the Raymond Irrigation district (1981)

Crop or Land Use	Percent of Irrigated Acreage
Barley	28
Alfalfa Hay	26
Wheat - hard	17
- soft	11
Pasture	7
Sugar Beets	3
Stubble (fall)	3
Grass Hay	2
Oats	1
Other (cereal silage, mustard, alfalfa seed, flax, green feed, gardens, summerfallow, squash)	2
TOTAL	100

Source: Annual Report and Financial Statement 1981, Raymond Irrigation District.

A study undertaken in 1953 found over 5,200 ha of land within the R.I.D boundaries to be slightly to strongly affected by soil salinity. Several factors were believed responsible for the problem soil salinity condition (8). These factors were:

a) inadequate natural drainage outlets,
b) poor external and internal drainage of some heavier textured soils associated with level topography,
c) canal and lateral seepage losses associated with coarser textured soils,
d) a combination of lighter surface soils and variable depths to till creating potential seepage problems downslope,
e) differential textural layers even in medium to heavy textured soils,
f) shallow depths to bedrock interfering with vertical subsurface water movement, and,
g) excessive applications of irrigation water and lack of control of excess drainage water.

Lack of markets and soil salinity problems have limited major crop production to legumes and cereals. The sugar beet factories closed down at Raymond (1963) and Picture Butte (1977) leaving Taber as the only market outlet. Plants were closed because:

1. The climate of the area was marginal for reliable quality sugar beet production.
2. Soil salinity problems made high yield per acre difficult to obtain.
3. The processing plant was small and inefficient.

Since transportation costs are mostly paid by the Sugar Company, sugar beet contracts that expire in the R.I.D. will likely be renewed with producers located closer to Taber.

Today a cost sharing program between the provincial government and the Irrigation Districts has allowed the R.I.D. to upgrade its drainage system and take steps to control leakage from the water delivery system. In addition, farmers are moving away from gravity irrigation to pivot and side-roll systems. The changes and improvements in district and on-farm water management are expected to have a positive impact upon the soil drainage and soil salinity problems that have plagued the district for so long.

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*Figures for irrigation and potential irrigation within Warner County include all of the R.I.D.

District officials anticipate an increase in assessed acreages with the expansion of the R.I.D. boundaries and improvements of the aging water delivery system. The District is expected to be able to serve over 18,200 ha once all improvements have been made.

Verdigris Coulee Project

Local interest in irrigation has been expressed through the Verdigris Coulee Committee since the early 1970's. Progress on the project continues (Fig. 50), with development of a water delivery system between Milk River Ridge Reservoir and Verdigris Lake via Middle Coulee (4).

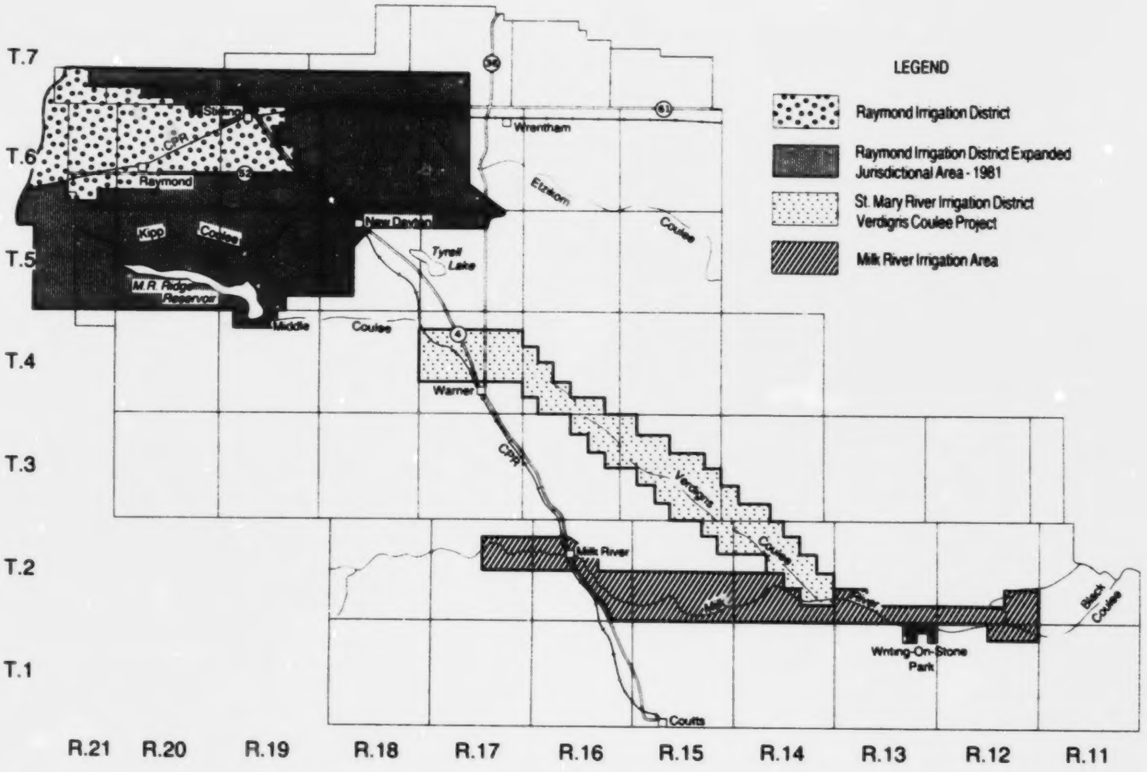

Fig. 50. Present and proposed irrigation projects in Warner County.

Irrigation water should have electrical conductivities less than 1 mS/cm and S.A.R. values should be less than 4 (5). Verdigris Lake water quality is marginal with electrical conductivity readings ranging from 0.5 - 1.1 dS/m and S.A.R. values of 2 to 5. Water quality would be expected to improve with addition of the water transferred from the Milk River Ridge Reservoir. In addition, the development proposal calls for the periodic flushing of Verdigris Lake into the Milk River system provided lake and river water levels are adequate (4).

Once the Verdigris Coulee Project is complete, there will be enough water to supply approximately 3,700 ha. All lands are to be serviced from the lake itself with no canal delivery system to be established. Topography will probably limit irrigation to sprinkler systems. The high cost of pumping from Verdigris Lake should stimulate conservation of water and help prevent overirrigation and subsequent drainage problems.

Irrigation Along The Milk River

Irrigation activity began in the Milk River Basin in 1903. At that time, the United States Government took steps to divert water from the St.Mary River to the Milk River, for eventual use in eastern Montana. Unhappy with the prospect of losing irrigation water from the St. Mary River, Canada countered by constructing a canal from the Milk River. The Canadian canal was to divert water from the Milk River northward around the eastern edge of the Milk River Ridge to the Magrath area. Also, the canal was to act as a deterrent to the United States plan to divert water from the St. Mary River. The apportionment problem was eventually overcome through the Boundary Waters Treaty Act of 1909 and finally resolved by the International Joint Commission in 1921. The United States is now entitled to more than half of the natural flow of the Milk River, by order of the Joint Commission (3). Today most of Canada's legal share of the Milk River passes through into the United States relatively unused. The canal built to divert water from the Milk River to Magrath was never used to transport water.

Irrigation has been practiced along the length of the Milk River for some time, most of it within Warner County

(Fig. 50). Present water use is based primarily upon minimum river flow. In 1979, twenty-eight sprinkler and 14 gravity irrigation projects were considered active. These projects involved 1,790 ha (3).

Proper water storage facilities developed within the Milk River Basin could supply a reliable source of water for approximately 8,100 ha of irrigation. Direct pumping from the river would likely be the least expensive development option. A dam near the forks in the Milk River has been proposed. This structure could help stabilize river flows (3).

Since most of the current irrigation activity is located near the Milk River townsite, future development would most likely see installation of direct pumping projects in this same area.

Limited soil water holding capacity due to coarse textured soils, and potential drainage problems associated with shallow depths to glacial till, could result in irrigation management and soil drainage problems in some areas. However, with direct pumping from the river and no canal systems, potential problems could be minimized. Pivot irrigation systems currently operating over coarser textured fluvial and eolian materials west of Milk River town appear to be successful.

Present water supplies coupled with potential water storage, conservation, and development projects, could increase the irrigated acreage in Warner County by 68% to 30,000 ha over the next decade. This further development is likely to occur within the new Raymond Irrigation District expansion area, the Verdigris Coulee Project, and in areas accessible to water along the Milk River. Once irrigation has developed to 30,000 ha, it is unlikely that further expansion could occur, due to limitations in water supply.

Cereal and forage crop production dominate the irrigation scene in Warner County at present. This trend will likely continue until markets for specialty crops can be developed further.

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3.4 RANGELANDS IN WARNER COUNTY*

Rangelands in the County of Warner have been used for cattle grazing over the past 100 years. Although most of the level and moderately rolling tracts of land are now farmed, much of the steeply rolling, stony areas and eroded, shallow, sandy or saline soils support native grass and are used by grazing animals.

Proper management of these rangelands is very important in maintaining a balance among the productive forage species. The main objective in range management is to provide the proper care and use of the range to get the highest continuous yield of animal products without endangering the soil and water resources and other land uses. The chief tool of range management is grazing control.

Through grazing control, rangelands can be maintained in a productive condition. This can be accomplished by following the principles of range management, which are: balance the number of animals with the available forage supply, distribute the animals evenly over the range and control the period of grazing and rest to manage and maintain the vegetation.

The productivity of rangelands, in terms of the number of hectares needed to supply feed for a mature beef cow or its equivalent, varies with the vegetation. Vegetation types closely follow soil types, both being influenced by climate and topography. Within an area dominated by one vegetation type, variations in soils, exposure, and drainage generally result in differences in species composition.

The vegetation of rangelands in the County of Warner is influenced by the cool high elevations of the Milk River Ridge and the northern slopes of the Sweet Grass Hills, and the drier, rolling plains which cover most of the area.

The tallest grasses grow on the Milk River Ridge. The vegetation there is typical of the Fescue Grassland Association, which is representative of the higher, moister areas. The principal grass species is rough fescue (Festuca scabrella), which may be completely dominant on some sites or codominant with northern porcupine grass (Stipa spartea var. curtiseta) on other sites. Other grasses of importance are Idaho fescue (Festuca idahoensis), Junegrass (Koeleria cristata), wheatgrasses (Agropyron spp.), Columbia needle grass (Stipa columbiana), and Hooker's oatgrass (Helictotrichon Hookeri).

On drier sites, Idaho fescue replaces rough fescue and forms a transition zone where it dominates and grows in association with western porcupine grass, Junegrass, and wheatgrasses. Other grasses in this vegetation type are needle-and-thread (Stipa comata), blue grama (Bouteloua gracilis), green needlegrass (Stipa viridula), wild oatgrass (Danthonia intermedia), and plains reedgrass (Calamagrostis montanensis). Threadleaved sedge (Carex filifolia) and low sedge (Carex eleocharis) also occur on this rangeland. This vegetation type forms a transition zone between the Fescue Grassland and Mixed Prairie association.

On the dry plains, short and medium tall grasses are typical of the Mixed Prairie Association. The dominant grasses are blue grama, neelde-and-thread, and northern (Agropyron dasystachyum) and western (Agropyron smithii) wheatgrasses. They grow in association with other grass species which may be relatively sparse or rather abundant. These species include Junegrass, Sandberg's bluegrass (Poa secunda), western porcupine grass and green needlegrass. Low sedge and thread-leaved sedge are also present.

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The most common and conspicuous forbs on the Milk River Ridge are prairie crocus (Anemone patens), northern bedstraw (Galium boreale), American hedysarum (Hedysarum alpinum var. americanum). and silvery lupine (Lupinus argenteus). On the dry plains, moss phlox (Phlox hoodii), goldenbean (Thermopsis rhombifolia), tufted fleabane (Erigeron caespitosus), and scarlet mallow (Malvastrum coccineum) are common.

Shrubs include shrubby cinquefoil (Potenilla fruticosa), silverberry (Elaeagnus commutata), and western snowberry (Symphoricarpos occidentalis) in the Milk River Ridge area and silver sagebrush (Artemisia cana), saltsage atriplex (Atriplex nuttallii) and pasture sage (Artemisia frigida) in the adjacent areas.

Trees are uncommon although western cottonwood (Populus sargentii) is found locally along river banks and in isolated moist valleys. Willow (Salix spp.) is fairly common along river banks.

The most productive rangeland on the Milk River Ridge is the Fescue Grassland where average yields vary from 800 to 1600 kg of forage/ha. The stocking rates on good to excellent range are from 0.4 to 0.8 ha/animal unit month (AUM). On the slopes in the transitional zone, forage yields average from 600 to 900 kg/ha. The stocking rates on good to excellent ranges are from 0.7 to 1.1 ha/AUM. The Mixed Prairie range on the dry plains yields from 350 to 600 kg of forage/ha, with stocking rates of 1.1 to 1.8 ha/AUM on range in good to excellent condition.

On ranges where heavy grazing has occurred, the compositon of the vegetation has changed and productivity has declined. On the Fescue Grassland ranges, rough fescue disappears when grazed heavily and is replaced by shorter grasses such as Idaho fescue, wheatgrasses, Junegrass, blue grass (Poa spp.), and sedges. Unpalatable forbs and shrubs such as pussytoes (Antennaria spp.), pasture sage, and shrubby cinquefoil, increase with heavy grazing. In the Mixed Prairie areas, heavy grazing results in a reduction of needle-and-thread, Junegrass, and the wheatgrasses, while blue grama, Sandberg's bluegrass, and low sedge, as well as pasture sage, broomweed (Gutierrezia diversifolia), plains prickly pear (Opuntia polyacantha), moss phlox, and little clubmoss (Selaginella densa) increase in abundance. These changes in vegetation result in the rangeland degrading to poor or fair condition.

To prevent overgrazing of native rangeland, the stocking rate should be set to provide a carryover of about 45% of the current year's growth of grass. Carryover is the grass that remains ungrazed at the end of the grazing season. A carryover of 45% may not be possible every year as forage yields vary widely from year to year. However, rangeland is not damaged by overuse during dry years if growth and carryover are low because the range will regain vigor during wet years when growth and carryover are high. Therefore, the stocking rate should be such that, over several years, the carryover average 45%.

3.5 WATER HOLDING CAPACITY AND ARIDITY INDEX

The retention of water for plant use is one of the essential functions of soil. However, soils differ in their capacity to hold water and in the semiarid conditions of southeastern Alberta this can become a critical factor in land capability and use. Two aspects are involved. First, is the amount of water the soil can hold in a plant available form - the Available Water Holding Capacity (AWC). Second, is the relationship between the amount of water which could be used by a crop compared to the amount of moisture available from the soil and from precipitation. On the prairies there is nearly always a moisture deficit which is expressed in this report as the Aridity Index. Both the AWC and Aridity Index are important factors for the planning and development of soil management practices.

3.5.1 Available water capacity.

Soils are frequently rated with respect to the quantity of water they store in so-called available form. This available water holding capacity of soils (AWC) has been defined as the difference between the amount of water in the soil at near saturation and the point where plants permanently wilt. In practice the AWC is calculated from soil moisture retained by soil at 1/3 and 15 atmospheres of pressure.

The AWC, computed for each recognized series in Warner County, is based on results of routine analysis of samples collected during soil survey. The water retention values for 1/3, 15 atmospheres and for the bulk density were either determined directly or predicted. Predicted values are based on regression equations modified from de Jong (8) using such factors as particle size distribution, organic matter content and in the case of bulk density, $CaCO_3$ equivalent. The AWC was computed to an effective rooting depth of 120 cm (Table 8). Final adjustment of AWC was made with respect to the stone content of individual soils. AWC ranged from a low of 18 mm for the gravelly NED soil to a high of 267 mm for fine textured KGT soil. The range of AWC values was then divided into 6 classes (Table 9). Individual map units were assessed with respect to the AWC of the component series and assigned to the established classes (Table 23). The only map units not assigned an AWC class are the miscellaneous unit RB, DL and S.

TABLE 8. Available water capacity of selected soils in Warner County (mm per effective depth of 120 cm).

Series	Family particle size	AWC
NED	SSK	18
CVD	S	41
KSR	COL	67
SXT	COL	93
RAM	FNL SSK	98
CFT	FNL SSK	108
MAB	FNL	155
RDM	FNL	155
MSN	FNL	159
CFD	FNL	159
CRD	FNL	166
CLD	FNC	227
KGT	FNC	267

TABLE 9. Classes of available water holding capacity

(mm per 120 cm)

0.	extremely low	<20
1.	very low	20-60
2.	low	60-120
3.	medium	120-180
4.	high	180-240
5.	very high	>240

The AWC class numbers in denominator part of symbol on the map (Fig. 51) show that most of the area is occupied by soils with medium AWC (120-180 mm). Soils with low AWC occur on coarse fluvial material along Milk River. The largest area of soils with moderately high AWC is associated with finer lacustrine deposits in the vicinity of Stirling Lake with additional small areas scattered throughout the county. Soils with AWC higher than 240 mm occur in only a few small locations.

3.5.2 Aridity Index

Several maps of annual water deficiency have been compiled for Canada in recent years (7, 25). These maps provide good information on aridity of various geographical regions caused by climatic conditions. However, they do not reflect a contribution of the soil component to local droughtiness.

A new concept, based on aridity indices, was used in Saskatchewan by Shields and Sly (23) to display droughtiness due to both climatic and soil conditions. The aridity index was defined as the long term average supplemental water required to maintain plant available water content of a soil under perennial crop at a level greater or equal to one-half of capacity throughout the growing season. This concept gives a practical assessment of overall aridity.

Sly computed supplemental water requirements for alfalfa and selected AWC for a number of climatological stations in Alberta (Table 10). These supplement values were used to set up 11 aridity classes (Table 11), seven of which occur in Warner County.

Aridity indices for perennial crops in Warner County are based on AWC values for individual map units and water deficit values for Alfalfa. The influence of climatic conditions in the Brown, Dark Brown and Black Soil Zones and six AWC classes on aridity in Warner County is shown in Table 12. Finally, aridity classes were assigned to individual map units (Table 23) and a map was compiled (Fig. 51). The compound symbol with aridity class in the numerator and AWC class in the denominator was used to display simultaneously both the overall aridity and the water storage capacity.

The map shows the spatial distribution of aridity and the influence of soil and climatic factors on droughtiness in Warner County. The influence of the climatic factor is ex-

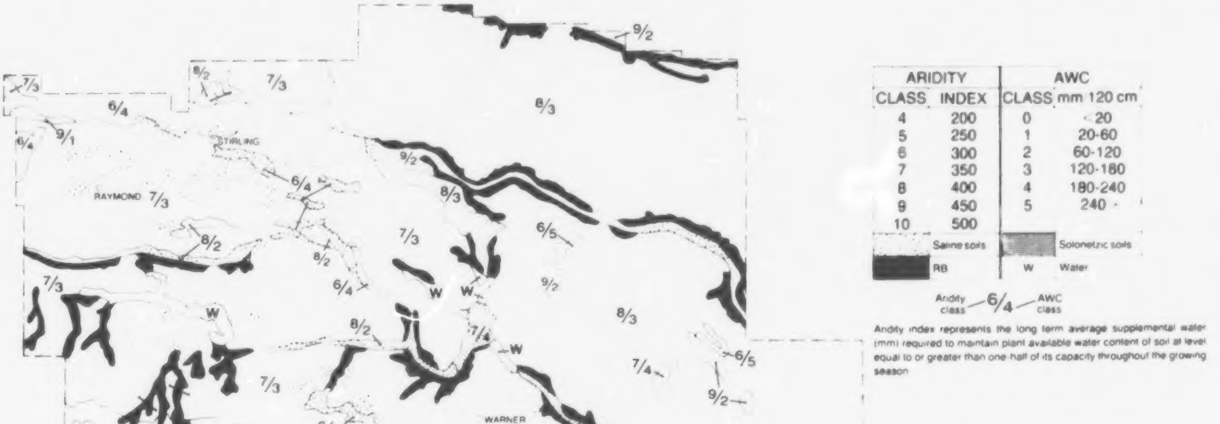
STIRLING
RAYMOND
WARNER
ARIDITY
CLASS INDEX
4 200
5 250
6 300
7 350
8 400
9 450
10 500
AWC
CLASS mm 120 cm
0 <20
1 20-60
2 60-120
3 120-180
4 180-240
5 240<
Saline soils
RB
Solonetzic soils
W Water
Aridity class — 6/4 — AWC class
Aridity index represents the long term average supplemental water (mm) required to maintain plant available water content of soil at level equal to or greater than one-half of its capacity throughout the growing season

Fig. 51. Aridity and available water holding capacity distribution in Warner County.

TABLE 10. Supplemental water requirements for perennial crops for selected climatological stations in southern Alberta.

Station	Soil Zone	Available Water Capacity (mm/class) 100/2	150/3	200/4	280/5
Foremost	Brown	453	407	392	345
Milk River	Brown	471	427	409	382
Lethbridge	D. Brown	407	363	326	289
Raymond	D. Brown	406	361	329	285
Cardston	Black	351	291	259	209
Pincher Creek	Black	354	298	272	224

TABLE 11. Aridity Classes and supplemental water requirements*

Aridity Class	Index	Degree of severity	Water supplement mm
0	0	negligible	0-25
1	50	v. slight	25-75
2	100	slight	75-125
3	150	v. low	125-175
4	200	low	175-225
5	250	moderate	225-275
6	300	high	275-325
7	350	v. high	325-375
8	400	severe	375-425
9	450	v. severe	425-475
10	500	extreme	475 +

* based on alfalfa, after Sly and Sly, 1984.

TABLE 12. Aridity classes in relation to soil zone and available water holding capacity

Soil Zone	Available Water Capacity Class 0	1	2	3	4	5
Brown	10	10	9	8	7	6
D. Brown	10	9	8	7	6	5
Black	9	8	7	6	5	4

pressed by a general decrease in aridity index value from the east to the west. This reflects the higher precipitation and lower evapotranspiration in the Black Soil Zone as compared to the Dark Brown and Brown Zones. However, higher AWC of soil can compensate for some increase in evapotranspiration, therefore soils with medium AWC in the Black Soil Zone and soils with moderately high AWC in the Dark Brown Soil Zone north of Raymond are both in class 6. The soil factor becomes dominant on soils with extremely low AWC. These very coarse textured fluvial deposits along the Milk River have the highest aridity index (500-class 10) despite changes in climate from Brown to Dark Brown Soil Zone.

Special patterns were used on the map to indicate a high proportion of Saline and Solonetzic soils. In these soils moisture stress is enhanced by the high concentration of salts in these soils, thus making prediction of Aridity indexes and AWC values less reliable. In the case of Solonetzic soil the impeding effect of salts is enhanced by poor physical properties of soil.

3.6 AGRICULTURAL INTERPRETATIONS

Proper soil management and land use planning requires soil information which is best obtained through a soil survey. Soil surveys provide information on soil properties and distribution and consolidates this information into evaluations of soil performance. The soil resource of Warner County was evaluated (or rated) according to its performance for three agricultural uses including dryland agriculture, irrigation, and grazing. Table 13 gives the map unit rating for the three agricultural uses, along with major limitations responsible for the rating.

In Table 13 each limitation is represented by a single letter. They are defined as follows:

C - adverse climate, insufficient precipitation and/or shortened growing season due to low temperatures
D - undesirable soil structure, usually Solonetzic soils
E - erosion damage
G - geological deposit (parent material), its uniformity or depth
M - low available moisture holding capacity
N - excessive salinity
P - excessive stoniness
R - shallow to bedrock, usually softrock
T - adverse topography, either steepness or slope pattern
W - excessive wetness

TABLE 13. Agricultural rating and limitations of Map Units in Warner County.

Map Unit	Irrigation Classification	Capability for		Grazing[4] Productivity
		Irrigation[2]	dryland[3]	
ANBV1/3	2L[5]	2L	5M	5M
ANBV1/4	2L	2L	5M	5M
BUT1/3-2	2L	2L	4M	5M
BUT3/3-2	5N	5N	5^{N}_{M}	5N
BV G4/4	3M	3M	5M	5M
BV L1/3	6R	6R	5^{M}_{R}	5M
BZR1/4	2G	3C	3T	2C
BZR1/5	4G	4T	4T	2C
BZR1/5D-6D	6G	6T	5T	3T
BZR2/4	5WJ	5WT	$3^{8}_{T}6^{2}_{W}$	1
BZR2/5	5WJ	5WT	$4^{8}_{T}6^{2}_{W}$	1
BZR4/6D	6G	6T	6T	3T
BZRF1/5	4G	4T	5^{T}_{P}	2C
BZRF1/5D	6G	6T	5^{T}_{P}	2C
BZRF1/6	6G	6T	6^{T}_{P}	3T
BZRF2/5	5WJ	5WT	$5^{8}_{T}6^{2}_{W}$	1
BZSO2/4	5WJ	5WT	$3^{7}_{T}5^{3}_{W}$	1
CFD1/2-3	1	1	4M	4C
CFD2/3-2	5W	5W	$4^{8}_{M}5^{2}_{W}$	4C
CFD3/2-3	5N	5N	5^{N}_{M}	4C
CFBV2/3	5W	5W	$4^{8}_{M}5^{2}_{W}$	4C
CFCH7/3-2	3D	3D	4M	4C
CFMS3/3	5N	5N	5^{N}_{M}	4C
CFMS3/3:R	5NR	5NR	5^{N}_{N}	4C
CHN2/2	3W	3W	$4^{8}_{M}5^{2}_{W}$	3
CHN5/2	1	1	3C	4C
CHBV1/3-2:R	5R	5R	4M	4C
CLD1/2-3	1	2C	2C	3C
CLD3/2-3	5N	5N	3N	3C
CLD3/2-3:R	5NR	5NR	3N	3C
CLLE1/2	1	2C	2C	3C
CLLE1/2:R	5R	5R	2C	3C
CLR1/5	4G	4T	5^{E}_{T}	5E
CRD1/2	1	2C	3M	3C
CRD1/2:R	5R	5R	3M	3C
CRD1/3	2G	2C	3M	3C
CRD1/3:R	5R	5R	3M	3C
CRD1/4	2G	2C	3M	3C
CRD1/4:R	5R	5R	3M	3C
CRD1/4D	4G	4T	4T	3C
CRD2/3-4	5WJ	5WT	$3^{8}_{M}5^{2}_{W}$	2
CRD2/3-4:R	5WR	5WR	$3^{8}_{M}5^{2}_{W}$	2
CRD3/3	5N	5N	4N	3C
CRD3/3:R	5NR	5NR	4N	3C
CRD4/4	3E	3E	4^{M}_{E}	3C
CRD4/4:R	5ER	5ER	4^{M}_{E}	3C
CRD4/4D	4EG	4ET	4^{M}_{E}	3C
CRD4/4D:R	5TR	5TR	4^{M}_{E}	3C
CRD4/5	4EG	4ET	5^{E}_{T}	3C
CRD4/5:R	5TR	5TR	5^{E}_{T}	3C
CRD4/5D	6G	6T	5^{E}_{T}	3C
CRD6/3	2G	2C	3M	3C
CRD6/5	4G	4T	4^{T}_{M}	3C
CRD7/4D	5DG	5DT	3D	3C
CRD7/4D:R	6DTR	6DTR	3D	3C
CR P1/3-4:R	5PR	5PR	5P	3C
CRNE1/3:R	5MR	5MR	4M	4M
CRNE2/3:R	6NR	6NR	4M	4MN
CRWN1/3-2	1	2C	3M	3C
CRWN1/3-2:R	5R	5R	3M	3C
CRWN1/4	2G	2C	3M	3C
CRWN2/3	5WJ	5WT	$3^{8}_{M}5^{2}_{W}$	3C
CRWN6/3	2G	2C	3M	3C
CRWN7/3	3D	3D	3D	3C
CVD1/3	3M	3M	5M	5M
DHP1/2	6NW	6NW	6N	6N
DHP1/2:R	6NW	6NW	6N	6N
DL			7	6
FOKS1/3	2L	2C	4M	4M
G	6W	6W	5W	1
GEM3/2-3	6ND	6ND	5^{N}_{D}	4C
GLS1/2	6NW	6NW	6N	5N
GR:E1/3	6DE	6DE	6^{E}_{D}	5DE
GR:E1/3:R	6DE	6DE	6^{E}_{D}	5DE
HDHU1/3-4	5D	5D	4D	4C
HDHU1/3-4:R	6DR	6DR	4D	4C
HEG1/3	2G	2C	2C	3C
HEG7/3	3D	3C	3D	3C
HRK1/3-4	3M	3M	5M	5M
HRK1/3-4:R	5MR	5MR	5M	5M
HRK4/4	3M	3M	5M	5M
HRK4/4:R	5MR	5MR	5M	5M

Map Unit	Irrigation Classification	Capability for Irrigation[2]	Capability for dryland[3]	Grazing[4] Productivity
HNK4/5	4MG	4MT	6^{M}_{T}	5M
HRNE1/3	3M	3M	5M	5M
HRNE1/4	3M	3M	5M	5M
HU:E1/3-4	6DE	6DE	6^{E}_{D}	6DE
HU:E1/3-4:R	6DE	6DE	6^{E}_{D}	6DE
JAT3/2	6WN	6WN	5W	1
KBD1/2-3	2D	2D	4D	4C
KHO3/2-3	5ND	5ND	4^{N}_{D}	3DN
KHO3/2-3:R	6DR	6DR	4^{N}_{D}	3DN
KGT1/2	6D	6D	5D	3D
KNT1/4	3M	2C	3M	3M
KSR1/3	2M	2C	4M	4M
KSR1/4	2M	2C	4M	4M
KSR2/3	3WM	3W	$4^{8}_{M}5^{2}_{W}$	4M
KSR2/3:R	5WR	5WR	$4^{8}_{M}5^{2}_{W}$	4M
KS:G1/3:R	5PR	5PR	4M	4M
KS:G1/4:R	5PR	5PR	4M	4M
KSMG1/3	2M	2C	4M	4M
KSMG1/4	2M	2C	4M	4M
KSOA1/3	2M	2C	4M	4M
LET1/2-3	1	2C	3M	3C
LET1/2-3:R	5R	5R	3M	3C
LET3/2-3	5N	5N	4N	3C
LET3/2-3:R	5NR	5NR	4N	3C
LEK52/4	5WJ	5WT	$3^{8}_{M}5^{2}_{W}$	3C
LEK56/3-4	2M	2C	3M	3C
LEOA1/2-3	1	2C	3M	3C
LEOA1/4D	4T	4T	4^{T}_{M}	3C
LLD1/2-3	6N	6N	5N	4N
LLD1/2-3:R	6NR	6NR	5N	4N
LUP1/2-3	1	2C	3M	3C
LVY7/2	5DN	5DN	5^{D}_{N}	4ND
MAB1/3-4	2G	2T	4M	4C
MAB2/3	5W	5W	$4^{8}_{M}5^{2}_{W}$	4C
MAB3/4	5WJ	5WT	$4^{8}_{M}6^{2}_{W}$	4C
MAB4/4	3E	3E	4M	4C
MAB7/4	3D	3D	4M	4C
MA:P1/4	5P	5P	5P	4C
MACF1/3	2G	2T	4M	4C
MACF2/3	5W	5W	$4^{8}_{M}5^{2}_{W}$	4C
MACF7/3	3D	3D	4M	4C
MCN3/3-2	5N	5N	5N	5S
MCN7/3-2	5D	5D	5D	5S
MC:S1/2	6N	6N	6N	6N
MGCR1/3-4	2L	2C	3M	3M
MGHR1/4-5:R	5MR	5MR	4^{T}_{M}	4M
MKR1/3	3M	3M	6MT	5M
MSN1/3	2G	2T	4M	4C
MSN1/3:R	5R	5R	4M	4C
MSN1/4	2G	2T	4M	4C
MSN1/4:R	5R	5R	4M	4C
MSN2/4	5WJ	5WT	$4^{8}_{M}6^{2}_{W}$	4C
MSN3/3-2	5N	5N	4^{N}_{M}	4C
MSN3/3-2:R	6NR	6NR	4^{N}_{M}	4C
MSN3/4-3	5N	5N	4^{N}_{M}	4C
MSN4/4	3E	3E	4^{E}_{M}	4C
MSN4/4:R	5R	5R	4^{E}_{M}	4C
MSN4/5	4T	4T	5^{T}_{M}	4C
MSN6/3	2M	2M	4M	4C
MSN6/4	3MG	3MT	4M	4C
MSN6/5	4T	4T	5^{T}_{M}	4C
MSN7/4	3D	3D	4M	4C
MSN7/4:R	5DR	5DR	4M	4C
MS:P1/4-5	4PG	4PT	5P	4C
MSAN1/3	2L	2L	4M	4C
MSAN1/3:R	5R	5R	4M	4C
MSAN1/4	3LG	3L	4M	4C
MSAN1/4:R	5R	5R	4M	4C
MSCF1/3	2G	2T	4M	4C
MSCF1/3:R	5R	5R	4M	4C
MSCF2/3	5W	5W	$4^{8}_{M}5^{2}_{W}$	4C
MSCF2/3:R	5WR	5WR	$4^{8}_{M}5^{2}_{W}$	4C
MSCF7/3	3D	3D	4M	4C
MSCF7/3:R	5DR	5DR	4M	4C
NED1/4-3	5MP	5MP	5MP	5M
NED1/4-3:R	5MR	5MR	5MP	5M
PUN1/4-3	3M	3M	5M	5C
PUN1/4-3:R	5MR	5MR	5M	5C
PUR1/4	2G	3C	3M	3C
PUR1/4D	4G	4T	4^{T}_{M}	3C
PUR1/5	4G	4T	4^{T}_{M}	3C
PUR1/6D	6G	6T	6T	4T

Map Unit	Irrigation Classification	Capability for Irrigation[2]	Capability for dryland[3]	Grazing[4] Productivity
PUR2/5-4	5WG	5WT	$4_{T}^{8}6_{W}^{2}$	3C
PUR4/4	3E	3C	4_{M}^{E}	3C
PUR4/4:R	5ER	5ER	4_{M}^{E}	3C
PUR4/5	4GE	4TE	4_{E}^{T}	3C
PUR4/5D	6G	6T	5_{E}^{T}	4TE
PUR4/6D	6G	6T	6T	4T
PUR6/4	3M	3C	3M	3C
PUR7/4-3	3D	3C	3D	3C
PUR7/4-3:R	5DR	5DR	3D	3C
PUBZ1/4	2G	3C	3M	3C
PUBZ1/4D	4G	4T	3T	3C
PUBZ1/5	4G	4T	4T	3C
PUBZ1/5D	6G	6T	5T	3C
PUBZ1/6D	6G	6T	6T	4T
PUBZ2/4	5WG	5WT	$3_{M}^{8}6_{W}^{2}$	2
PURZ2/5	5WG	5WT	$4_{T}^{8}6_{W}^{2}$	2
PULU1/3-4	2G	3C	3M	3C
PULU1/3-4:R	5R	5R	3M	3C
PULU7/3D	3D	3D	3D	3C
PULU7/3D:R	5DR	5DR	3D	3C
PURF2/6	6G	6T	$5_{T}^{8}6_{W}^{2}$	3C
RAM1/3:R	5LR	5LR	4M	5M
RB1	6G	6T	6T	5T
RB2	6G	6T	6T	6TR
RB3	6G	6T	7RT	6TR
RB4	6G	6T	6T	4T
RDM2/4	5WG	5WT	$3_{M}^{8}6_{W}^{2}$	3C
RDM4/4	3E	3E	4_{M}^{E}	3C
RDWN1/3	2G	2C	3M	3C
RFBZ1/4	3PG	3C	4_{T}^{P}	3M
RFKN1/5	5PG	5PT	5_{T}^{M}	3M
RFKN2/4	5WP	5WP	$4_{M}^{8}5_{W}^{2}$	3M
S	6N	6N	6N	6N
SLY1/2	6W	6W	5W	1
SOF1/3-4	2G	3C	2C	2C
SOL1/4	2G	2C	3M	3C
SOL1/5D	6G	6T	5T	3C
SOL1/6D	6G	6T	6T	4T
SPS3/2	5N	5N	3C	4C
SXT1/2-3	2M	2M	4M	5M
SXT3/2-3	5N	5N	5_{M}^{N}	5M
TEP1/2	6W	6W	5W	1
VAC4/4-3:R	6ER	6ER	5_{R}^{S}	5SR
VAC7/3:R	6DR	6DR	5_{R}^{D}	5SR
VEB1/5	4EG	4ET	5_{T}^{E}	4E
VEB1/5:R	5GR	5TR	5_{T}^{E}	4E
VTR3/2-3	5DN	5DN	5_{N}^{D}	4DN
VTR3/2-3:R	6NR	6NR	5_{N}^{D}	4DN
WDW1/2	3D	3D	4D	5D
WID1/5	4G	4T	5_{T}^{E}	4E
WID1/6D	6G	6T	6_{T}^{E}	4ET
WLH1/2	3W	3W	5W	2
WNY1/2-3	1	2C	3M	3C
WNY1/2-3:R	5R	5R	3M	3C
WNY3/2-3	5N	5N	4N	3C
WNY3/2-3:R	6NR	6NR	4N	3C
WNCR3/3-2	5N	5N	4N	3C
WNCR3/3-2:R	6NR	6NR	4N	3C
WNLE1/2-3	1	2C	3M	3C
WTN1/3	3D	3D	5D	4D
WTN3/2	5N	5N	5_{N}^{D}	4DN

[1] Following the Land Irrigability Classification for Alberta (2)

[2] Capability for irrigation also recognizes a climatic limitation (see discussion)

[3] Following the Canada Land Inventory - Soil Capability for Agriculture (9)

[4] A 7 class system based on a Guide to range conditions and stocking rates for Alberta (24)

[5] Limitation symbol definitions

C - adverse climate, insufficient precipitation, heat or length of growing season
D - undesirable soil structure, usually Solonetzic soils
E - erosion damage
G - slope limitation (irrigation)
J - landscape pattern limitation (irrigation)
K - shallow soil profile (irrigation)
L - geologic layering, effects water movement
M - low moisture holding capacity
N - excessive salinity
P - excessive stoniness
R - shallow to bedrock
S - combination of soil factors
T - adverse topography (general term)
W - excessive wetness

3.6.1 Capability for Dryland Agriculture

Capability for arable agriculture was determined following the Canada Land Inventory - Soil Capability for Agriculture (11). This system uses seven classes based on the degree of limitation for agricultural use, the limitations becoming progressively greater from Class 1 to Class 7. Each class indicates the general suitability of the soils for agriculture. In this system the Subclass is a grouping of soils with similar kinds of limitations for agricultural use. Using this system, soil capability maps were published by the Canada Land Inventory program in 1970 for the Lethbridge Map Sheet (19), which covers the western half of Warner County, and the Foremost Map Sheet (18) which covers the eastern half.

Since these capability maps were derived mainly from soil surveys of several years ago (33, 34), a more current agricultural capability map (Fig. 52) has been prepared based on this latest soil survey of the county. Warner County is largely an area of relatively low capability for dryland agriculture mainly because of less than adequate moisture. Less than 20% of the county is Classes 1, 2 and 3 (Table 14)

Yield estimates for three dryland crops were prepared for the major soil climate combinations of Warner County (Table 15). Alberta Hail and Crop Insurance data (1976-80) were used for this purpose.

TABLE 14. Percent distribution of Agriculture Capability classes and subclasses in Warner County.

	Capability Class					
Limitation	2	3	4	5	6	7
Climate	1	-	-	-	-	-
Moisture	-	18	50	2	-	-
Salinity	-	-	-	4	-	-
Topography	-	1	3	11	7	-
Wetness	-	-	-	1	-	2
TOTAL	1	19	53	18	7	2

TABLE 15. Yield estimates for dryland crops in Warner County

		Yield (kg ha)	
Agroclimate	Capability	Spring Wheat[1]	Winter Wheat[1]
2A	3M	2000	2570
	4 ME	1890	
	4M	1820	2150
3A	4M 5W	2050	
	4M 6W	2180	

[1] grown on fallow, unfertilized

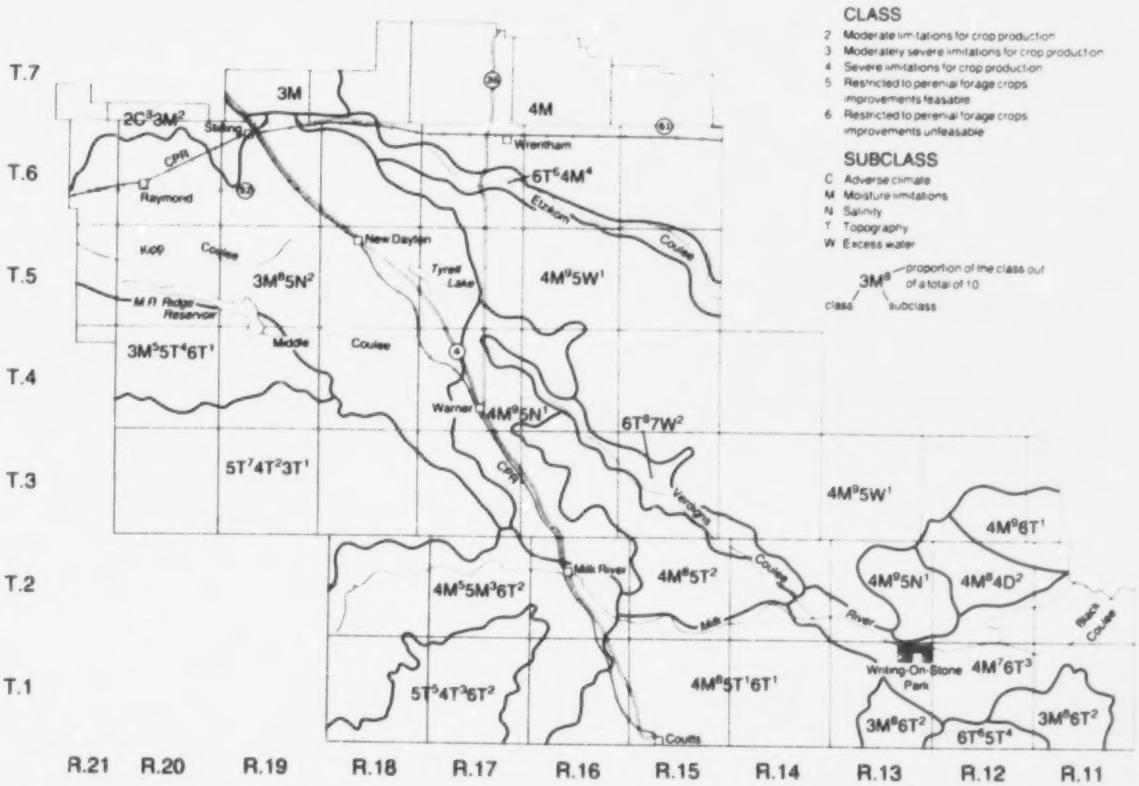

Fig. 52. Generalized soil capability map for agriculture.

When using these yield figures it must be borne in mind:

(1) The data apply only to Warner County and cannot be extrapolated to soils outside county boundaries.

(2) The actual yield figures will become outdated as farming technology progresses. However, the relative ranking of the soil-climate combinations is likely to remain constant.

(3) Only soils in the fine loamy (medium textured) group are included. This group represents the majority of soils in the county.

(4) The yield figures represent a five year mean. Large annual variations as well as farm to farm variations can be expected. Differences of 10% are considered to be significant.

For wheat there is a 10-20% reduction in yield when moving from Class 3 to Class 4 land. Map units containing wet areas (units $4M^7 5W^3$ and $4M^7 6W^3$) apparently produce a higher per hectare yield, possibly because of higher water tables supplying extra moisture. However, it is estimated that on the average, 20% of a $4M^7 5W^3$ unit and 30% of a $4M^7 6W^3$ unit would be non arable. Those yield reductions would be appropriate when calculating yields on a quarter section basis.

3.6.2 Capability for Irrigation

Capability for irrigation follows the same considerations as capability for dryland agriculture. Class 1 has no limitations while lower classes have increasing degrees of limitation. These limitations may be related to climatic, topographic or soil conditions.

Soil characteristics such as morphology, chemical composition, texture, depth of profile, parent material and salinity, all influence irrigability. The soil rating for irrigability used in this report (Table 13) follows the Land Irrigability Classification for Alberta (2). It is then modified by landscape and climatic considerations to arrive at a final capability.

The climatic consideration recognizes the restrictions due to shortness of growing season or lack of heat on the variety of crops which can be grown. Specialty crops are given a preference and a frost free period of less than 120 days or less than 1750 growing degree days (above 5C) has been placed in Class 2. Less than 90 days frost free period (Class 2 for dryland) is considered as Class 3 for irrigation capability. To determine the irrigability of an individual parcel of land it is necessary to collect and analyze soil samples which was beyond the scope of this soil survey. Nevertheless, the general irrigation potential of the county shown in Fig. 53 may be helpful.

Nearly half of the county has severe limitations for irrigation (Table 16) mainly because of the rough topography on the Milk River Ridge, and salinity associated with the shallow bedrock on Verdigris Plain. This table also indicates that climate is a significant limitation to irrigation resulting in about 1/3 of the county being rated as Class 2. This is primarily in the western and southwestern part of the county where shorter frost free periods exist. Only a minor portion of the county has no limitations, this primarily on Chin Plain.

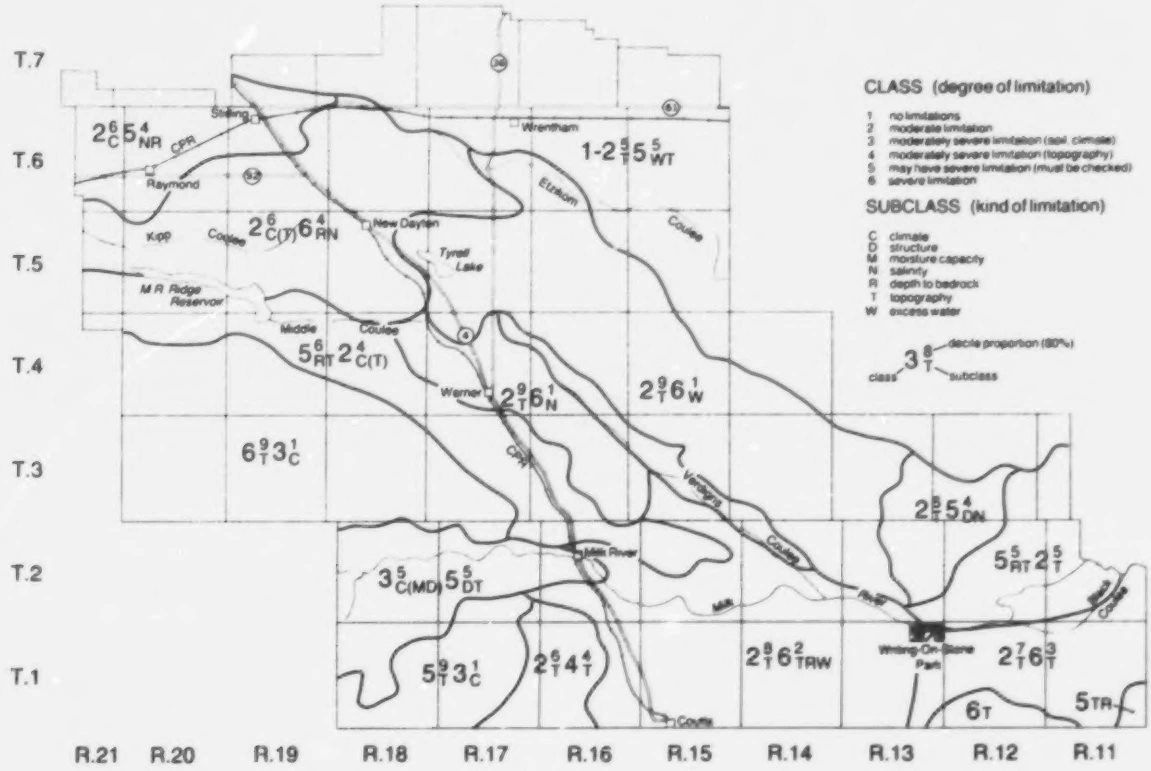

Fig. 53. Generalized soil capability for irrigation.

TABLE 16. **Percent distribution of irrigation classes and subclasses.**

Limitation	Irrigation Class 1	2	3	4	5	6	7
none	2	-	-	-	-	-	-
adverse climate	-	14	3	-	-	-	-
undesirable structure	-	-	2	-	-	1	-
erosion	-	-	4	-	-	-	-
geological layering	-	1	-	-	-	-	-
moisture capacity	-	1	3	-	-	-	-
salinity	-	-	-	-	3	1	-
shallow to bedrock	-	-	-	-	8	2	-
topography	-	23	-	4	1	11	-
wetness	-	-	1	-	12	1	2
Total	2	39	13	4	24	16	2

3.6.3 Grazing Capability

In Warner County grazing is largely confined to the Milk River Upland where rough topography makes it less desirable and often unsuitable for cultivated agriculture. This is primarily in the Upland areas. The carrying capacity for each map unit (Table 13) is an estimate based on the procedures outlined in the Guide to Range Conditions and Stocking Rates for Alberta (26). The carrying capacities are placed into classes according to the following table:

TABLE 17. **Rating classes for grazing capability**

Class	stocking rate* (ha/Auy)**	dry matter yield† (kg/ha)
1	<5	>1550
2	5-10	1550-775
3	10-16	775-500
4	16-24	500-325
5	24-36	325-220
6	36-60	220-130
7	>60	<130

* Assumptions include:

a) 12 kg/day requirement per animal unit

b) 45% carry over to maintain range

c) an average for "good" range conditions

** Hectares per animal unit year. To convert to acres per animal unit month divide by 5

† This is about 1/2 the potential yield under excellent conditions. For lbs/acre multiply by 0.9

3.7 SOIL DEGRADATION

Soil degradation, the wastage of the non renewable soil resource, is a very real problem in Warner County. This soil survey attempted to quantify the two most serious types of soil degradation - salinity and erosion.

3.7.1 Degradation by Salinity

Salinity, the more obvious of the two, occurs primarily on Verdigris Plain (Fig. 54) where depth to bedrock is shallow. Saline areas are of variable size ranging from very small areas of less than 1 ha, to those covering several quarter sections. Degree of salinity is also variable ranging from areas which are completely saline to those which are partially effected by salinity. During mapping, areas of 5 ha or less could not be delineated and appear on the map as "S" spot symbols (Fig. 45). Delineated saline areas are of two kinds - those which are dominantly saline and so identified by the map unit symbol (Fig. 32), and those which have a significant (20% to 40%) amount of salinity (Fig. 55), identified as "3" units on the map. In assessing and outlining saline areas the mapper depended heavily on visible salinity indicators such as salt crusts, salt tolerant vegetation and effected crops, occasionally correlated with electrical conductivity measurements.

With the effected areas outlined and identified with respect to size and degree of salinity, the areal extent was calculated. Using an average size of 2.5 ha for each "S" spot symbol, and the total salinity within each outlined area, it was determined that the area of saline soils totalled 15000 ha. This is 3.3% of the county area, and includes both dryland and irrigated salinity.

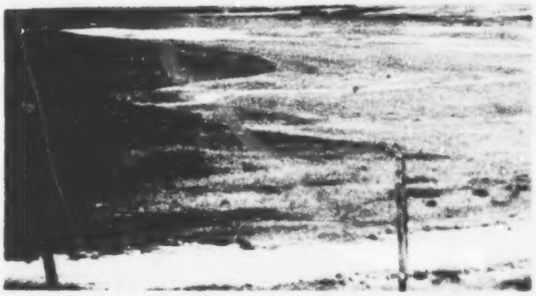

Fig 55. An area with significant salinity, a "3" area

Undoubtedly some below surface salinity exists adjacent to areas of surface salinity and a more realistic estimate of salinity could include an additional 7000-15000 ha as being slightly effected. This situation has in part been verified by Wilson* who found evidence of subsoil salinity in many areas where no surface salinity was evident.

An attempt was made to determine the rate of salinity increase in an 1100 ha (4 1/4 section) area about 9 km east of Milk River town. Using aerial photographs flown in 1952 and 1978 all saline areas were oultined and their area determined. The 1952 photographs indicated about 20 ha of salinity which had increased to 33 ha on the 1978 photographs. This 13 ha increase during that 26 year period represents a 65% increase. Assuming an equal annual increase, this represents a 2.0% increase in salinity each year. In terms of extent, in 1952 1.8% of the selected area was saline which increased to 3% by 1978. It is not known whether or not this rate will continue in the future.

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* Personal communication, F.H. Wilson, P.F.R.A. Lethbridge.

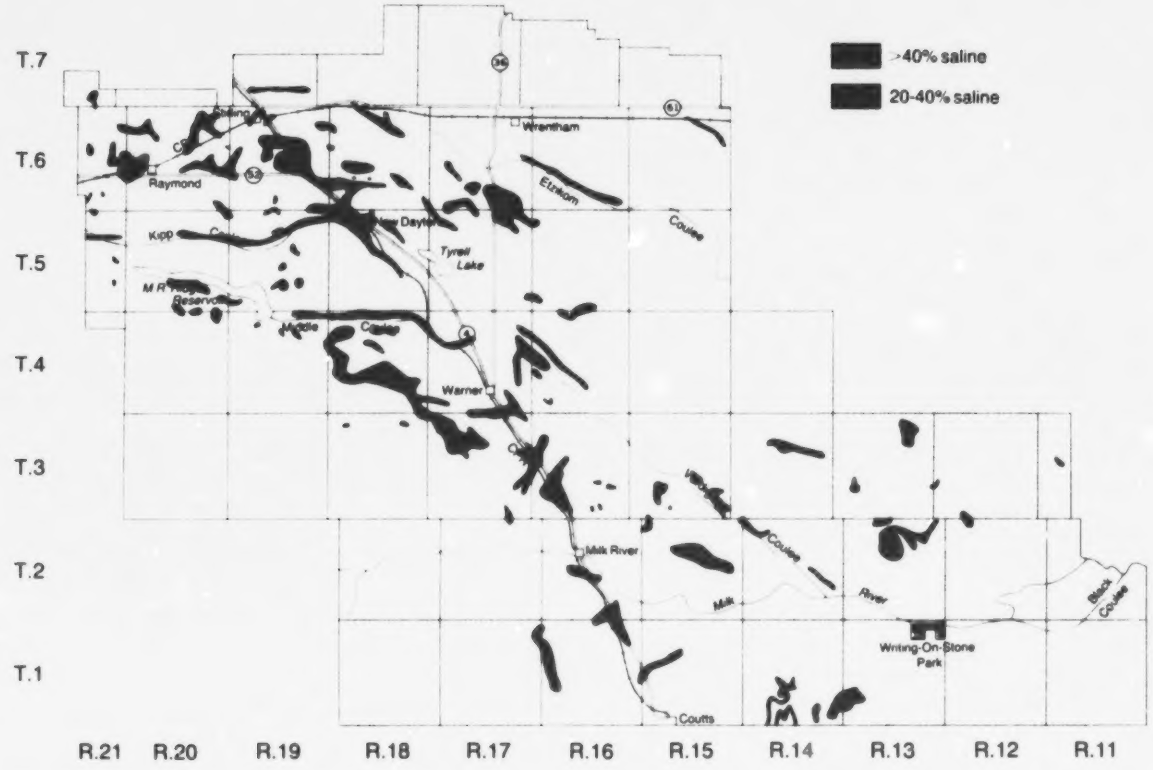

Fig. 54. Distribution of salinity in Warner County.

3.7.2 Dryland Saline Seepage and its Control**

Dryland saline seepage is a major soil problem in the County of Warner. Of particular concern is the continued increase in size and severity of the problem. The dryland saline seep problem occurs not only here but also in most other regions of the North Western Great Plains.

Saline seeps are characterized by:

a) artesian and high water table level conditions,
b) high concentrations of salt in the soil and water, and
c) salt tolerant vegetation.

As a result, the sites are often inaccessible to farm equipment, have reduced crop yields, provide poor quality stockwater supplies and act as a source of weeds. The predominant salts in these soils are sodium, magnesium and calcium sulfates. Total dissolved solid concentrations of 10-20,000 ppm and sodium absorption ratios (SAR) of 20 to 30 are common.

Recharge areas are located upslope of the dryland saline seep (Fig. 56). In the recharge areas, water in excess of the plant requirement and/or water holding capacity of the root zone, deep percolates. The "excess" water reaches the ground water table and starts or increases a lateral, downslope flow of ground water through one or more permeable strata in the overburden, bedrock, or bedrock contact. The groundwater travelling to the discharge area dissolves and picks up salts from the soil. In the discharge area, the water rises to the surface, mainly by means of capillary action. Research indicated that in a bare clay loam soil in southern Alberta, a net annual upward movement of water and salt can be expected when the water table remains for some time at less than 1 m from the surface. Dryland saline seeps are most common in regions with thinner layers of glacial overburden (E10 m), a large topographic relief and farm practices that are conducive to causing "excess" soil moisture.

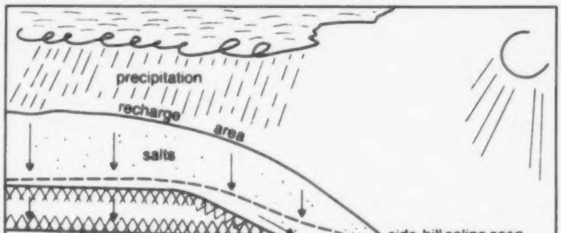

Fig. 56. How dryland saline seepage occurs.

** Prepared by: H.S.A. Vander Pluym, Alberta Agriculture, Lethbridge.

Prior to settlement, typical plant ecosystem (short and tall grass) on the prairies utilized all available moisture. Water table levels were low. Shortly after the turn of the century the prairie sod was broken and replaced with cereal crops, which because of their shorter growing season and root system use less moisture. Water table levels started to rise. This phenomena was aggravated by the subsequent introduction of summerfallow which is inefficient in storing mositure. Research indicated that in the Lethbridge area, of the 52 cm of the precipitation that falls during the 21-month fallow period, 39 cm (75%) is lost on deep percolation, runoff, and evaporation. The many natural and man-made temporary ponds visible in the spring also contribute greatly to the excess water.

Controlling dryland saline seepage is first directed toward preventing the problem and secondly towards reclaiming the saline seep. Preventive controls are carried out in the recharge areas. These type of controls are preferred because they are generally cheaper and more effective.

Preventive controls are:

i surface water drainage,
ii high moisture use crops, and
iii recropping.

Other controls, but which are applied in the saline seep:

iv subsurface drainage, and
v salt tolerant grasses.

Surface Water Drainage - of the intermittent natural and made-made ponds is an effective and inexpensive method of control. An open trench or buried pipe is used. Draining the intermittent ponds has several advantages:

a) it prevents deep percolation and saline seepage,
b) the drainage water is salt free,
c) the drained areas no longer delay spring operations,
d) the drained areas immediately yield excellent crops, and
e) outlets for upland ponds are easier to locate.

High Moisture Use Crops - such as alfalfa, should be planted in the recharge areas that contain deep (>1.5 m) and moist overburdens. The alfalfa will dry out the subsoil, lower the water table and restore a water storage reservoir in the soil. In the area immediately upslope of the saline seep, it will also intercept laterally moving ground water. Deep rooted forages, such as alfalfa, use more water than cereal crops and use it for a longer period during the growing season. They also extract moisture from a greater depth than annual crops (Table 18). In order to determine the extent of a recharge area and its rate of contribution, extensive hydrogeological investigations are required.

TABLE 18. Soil moisture extraction by various dryland crops (Brown, 1977, USDA, Montana)

Crop	Depth of Water Use (m)	Consumptive Use (cm)
Alfalfa	4.30	51
Sainfoin	3.25	42
Safflower	2.45	42
Russian Wild Ryegrass	2.15	32
Tall Wheatgrass	2.00	30
Sweet Clover	2.00	28
Winter Wheat	2.15	21
Barley, Spring Wheat	1.20	17

Recropping - using annual or bi-annual crops is recommeded on the recharge areas of fields prone to salinity and where alfalfa presently is not feasible. The decision to recrop depends foremost on the availability of an adequate spring soil moisture supply (Plant Available Water >10 cm). Special tillage and snow management practices are being researched to raise the level of spring soil moisture. Zero-till experiments in the Lethbridge area obtained an additional 10-30 mm P.A.W. Swathing at alternate heights raised P.A.W. levels 2-47 mm in the Swift Current area.

Subsurface drainage of saline seeps - can be a quick and highly successful control. But it can only be used for a few selective sites, those sites that contain coarse textured, permeable, water bearing strata within a reasonable depth (<3 m) from the surface. For the medium and fine textured soils, research is underway to determine their feasibility for drainage. Drain depth and spacing criteria are being developed for these and other types of soils. In general, subsurface drainage of dryland saline seeps is difficult because:

a) our fine textured glacial soils have low permeabilities (±5X10-2 m/day), except where fractures exist;
b) the low permeability is aggravated by the sodic, dispersed conditon of many saline seep soils; and
c) the semi-arid climate provides little water for salt leaching under dryland conditions.

Salt tolerant grasses - have been the most accepted control by farmers. Salt tolerant grasses are preferred over salt tolerant cereal crops because the latter in the saline seep will do little in slowing down salinization, as a matter of fact salinization will continue and reach a point where it will even be difficult to establish forages. Some of the common salt tolerant grasses are: Altai Wild Ryegrass, Slender Wheatgrass, Tall Fescue, and Crested Wheatgrass.

The success in controlling dryland saline seepage will to a great extent depend on the cooperation between neighboring farmers, on whose land the recharge area or a drainage outlet is located. It will, to a similar extent, depend on the farmer's willingness to alter his farming practices and spend time and money on controlling the problem.

3.7.3 Degradation by Erosion

Under a natural vegetative cover, the risk of soil erosion would be slight on the western Prairies. However, as man plowed the native sod and allowed overgrazing, the undue exposure of soil to wind and water has greatly increased the risk of soil degradation by erosion.

Although wind and water tend to function under different circumstances, both lead to removal of the nutrient rich topsoil. Deposition of the eroded material in ditches, or on other land, causes additional damage, especially when agricultural chemcials are washed into streams and lakes along with erosion materials. Thus the negative effect on our environment can be very broad and far reaching.

Soil erosion is a two-step process. The first step is detachment where small soil particles or aggregates break away at the soil surface. Whether or not detachement will occur depends on the ability of particles to resist the erosive force of wind or water. Well aggregated, humus rich and fine textured soil, will erode less rapidly, than coarser textured, sandy or silty soils. The second step is transporation, which results in actual soil loss.

Both wind and water provide energy for soil detachment and transportation. Their effectiveness, however, depends on conditions which differ in many ways. For example, water erosion can occur only if the precipitation intensity exceeds infiltration. On the other hand, wind erosion occurs independently of slope or infiltration capacity depending only on wind velocity and surface cover. Wind erosion will occur during periods of drought, water erosion during high intensity rain or fast snowmelt. For these reasons they must be treated separately.

Water erosion

Soil erosion by water includes sheet, rill and gully erosion. While gully erosion is most visible, sheet and rill erosion cause the highest loss. Some visible signs of erosion were observed in Warner County such as:

a) Rill formation after heavy late spring and early summer rains (Fig. 4)
b) Accumulation of fresh soil deposits at the base of steep or long slopes (Fig. 57)
c) Erosion of knolls in a hummocky area which is indicated by accumulated material downslope.

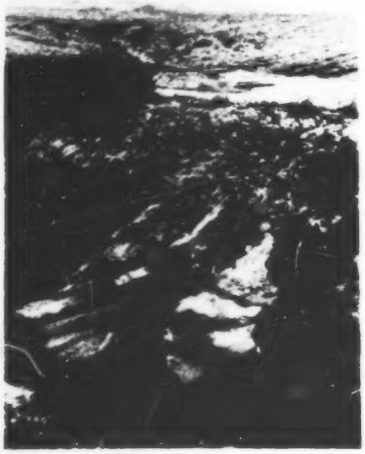

Fig. 57. Soil accumulation from gully erosion.

Water erosion occurs under a variety of conditions with the main agents being rainfall and melting snow.

Erosion by rain is caused by the impact of raindrops on the unprotected soil surface or by runoff water. Sheet erosion is caused by a combination of raindrop dispersion and movement of shallow water across the soil surface, while rill and gully erosion results from chanalized flow of runoff waters.

The most widely used method of soil loss prediction is the Universal Soil Loss Equation (USLE) devised by Wischmeier and Smith (31) which is: A = RKLSCP.

The soil loss, A, is based on six major factors controlling the erosion of soil from agricultural land: a rainfall factor (R); a soil-erodability factor (K) (Table 19); a slope length and slope steepness factor (LS); a croppingmanagement factor (C) (Table 20); and an erosion-control practice factor (P).

TABLE 19. "K" factors for selected soils in Warner County.

				Erodibility	
Soil	PM	Text.	Class	K factor	Class
Cavendish	fluv.	LS	O.B.	0.020	1
Kessler	fluv.	SL	O.DB	0.026	2
Beazer	till	L	O.BL	0.026	2
Cradduck	till	L	O.DB	0.034	3
Masinasin	till	L	O.B.	0.040	3
Lethbridge	lac.	L	O.DB	0.034	3
Verburg	till	L	R.DB	0.040	3
C-horizon	till	L	-	0.050	5
Hemaruka	till	L	B.SS	0.045	4

It should be noted that exposed calcareous subsoils have K values usually exceeding 0.35 which highlights the point that soils become even more susceptible to erosion as the process progresses.

TABLE 20. Cropping management factor "C" for Warner County*

CROP	FACTOR
Summerfallow-spring wheat	0.39
Summerfallow-winter wheat	0.29
Spring wheat	0.22
Alfalfa	0.025
Grass	
Black soil zone	0.004
Dark brown soil zone	0.006
Brown soil zone	0.010

* Calculations based on Wischmeier (30)

Values for the various factors were calculated for individual soils and landscapes in Warner County. They were then applied to the soil map units by considering the various soil components of each unit (Table 21). A complete list may be found in Appendix D.

Results of predicted soil loss using the USLE show a wide range in erosion potentials (Appendix D). The main controlling factors are slope characteristics and soil texture. Assuming bare soil (potential erosion), the lowest calculated value was 1.5 t/ha/yr for the CRD 1/2 map unit, which has slopes of less than 2%. The highest value was 100 t/ha/yr on the WID1/6D map unit which has slopes over 15%. A generalized potential erosion map is shown in Fig. 58.

Actual erosion, however, (Fig. 59) is much lower because of vegetative cover (Table 21), and is mainly restricted to the cultivation of areas with steep or extremely long slopes associated with the Milk River and Sweet Grass uplands.

It is estimated that over 40,000 ha (9%) in Warner County have been severely affected by erosion most of which appears to be due to erosion by water. Left unchecked, soil erosion will continue to increase at still faster rates.

TABLE 21. Predicted soil loss for some map units in Warner County.

		Average Slope				Soil Loss[1] (t/ha/yr)		
Map Unit	Landform	Gradient %	Length m	LS Factor	K Factor	Bare Soil	Spring Wheat Summerfallow	Grass
CRD1/2	gently undulating	2	50	0.2	0.034	1.5	1.1	< 1
CRD1/3	undulating	5	25	0.38	0.034	5.6	2.2	< 1
CRD1/4	hummocky	6-9	30	1.10	0.034	16.3	6.3	< 1
CRD1/4D	inclined & dissected	6-9	< 100	1.50	0.034	22.2	8.6	< 1
CRD1/4R	inclined	6-9	200	2.00	0.034	29.6	11.5	< 1
CRD4/5	hummocky	10-15	50	2.50	0.036	42.6	18.0	< 1

[1] Based on Annual Rain Factor = 33 (based on 2 year return of 6 hours precipitation records for Lethbridge Airport and the method by Athesian. (4).

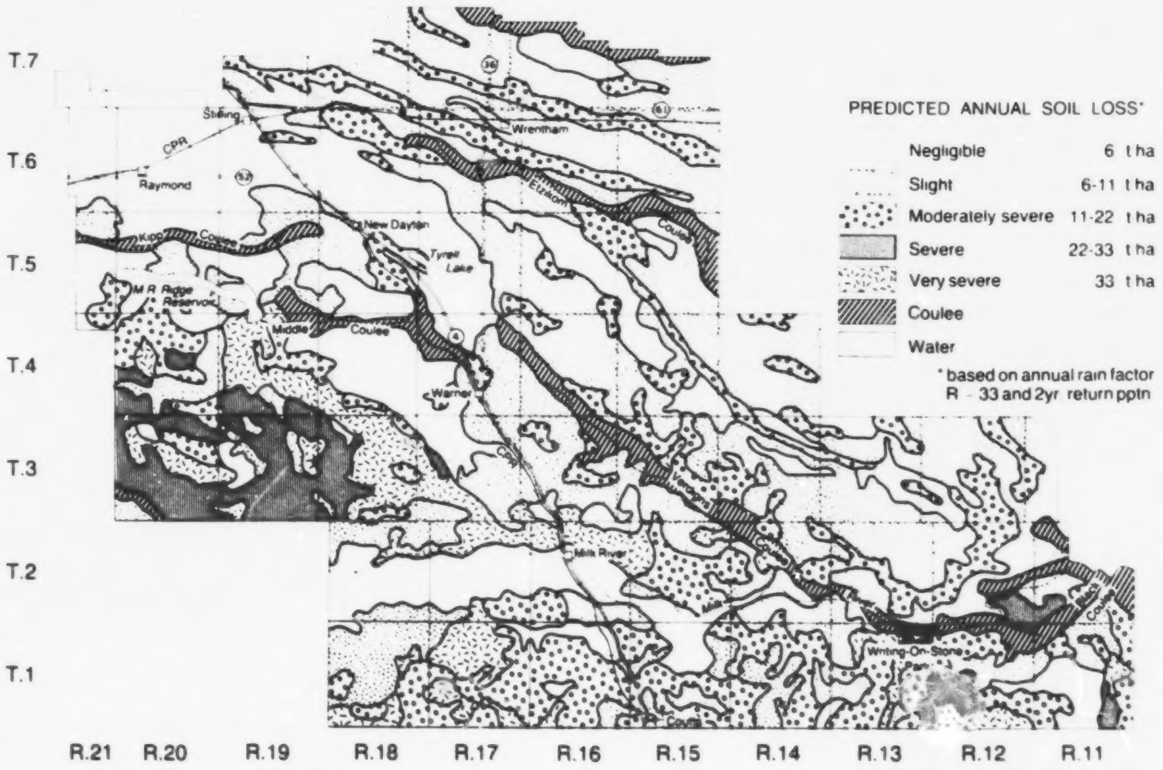

Fig. 58. Water erosion potential of soils in Warner County.

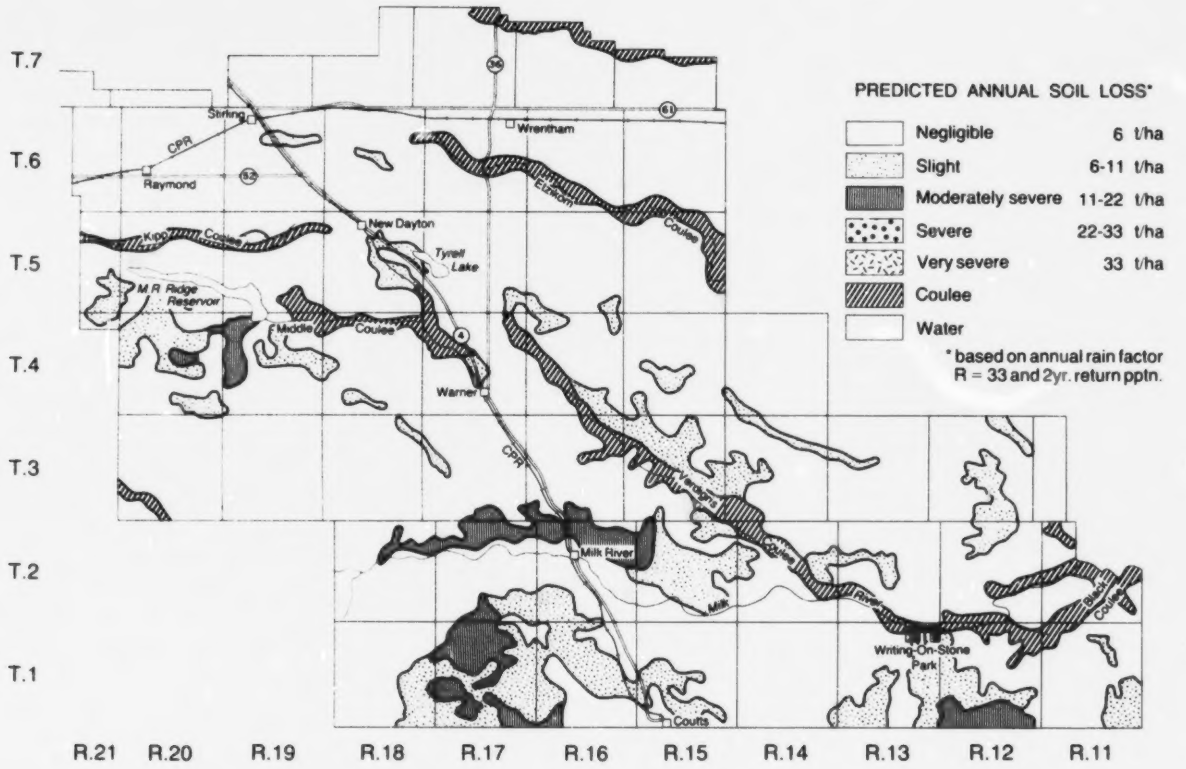

Fig. 59. Actual erosion by water in Warner County.

It is obvious, that some erosion will be associated with intensive large scale farming. Soil losses, however, must be kept at a minimum in order to sustain present productivity. This requires the recognition and use of erosion control practices. Such practices as minimum tillage, contouring or contour strip cropping or maintaining a surface cover, would reduce soil losses to a minimum. Toogood (28) properly pointed out that erosion control practices are designed to increase infiltration and reduce runoff, therefore also leading to greater moisture effeciency.

Wind Erosion

Soil erosion by wind has long been recognized in southern Alberta where widespread devastation occurred during the first third of this century. As a result, governments developed research and extension programs to combat this problem. Today, although wind erosion losses are lower, the risk of drifting soil persists (Fig. 5).

Five factors are important to wind erosion (a) climate, (b) inherent erodibility of the soil, (c) degree of roughness of the soil surface, (d) the kind and amount of cover provided by plants, residue or other obstructions to wind flow and (e) width of the area of soil exposed to direct action of wind.

Known for its high winds and arid climate, the risk of wind erosion is high in Warner County. Under these conditions, soil with small aggregates or low resistence to detachment, will be the most susceptible to wind erosion. Soil with fine sandy to fine loamy sand surface textures such as KSR or CVD are the most susceptible. Soils with the lowest susceptibility are those with clay loam and silty clay loam textures (MAB, SOL, PUR) which tend to form larger and more stable aggregates. Soils in the brown zone are more susceptible to wind erosion than soils in the black zone, because they have higher moisture deficits and lower organic matter contents.

Surface roughness aids in the control of wind erosion by causing entrapment of moving soil particles. Leaving the soil surface in a cloddy state, with cultivation ridges at right angles to the prevailing wind direction, will result in less erosion than leaving the soil in a smooth pulverized state.

Crop residues offer good protection from wind erosion hence the recognized management practice of stubble mulching, and the use of noble blades and rodweeders. Field width is a very important factor in wind erosion, hence the practice of strip farming with strips oriented at right angles to prevailing winds. Although the technologies to combat wind erosion are known, they may need to be used more diligently.

3.8 ENGINEERING INTERPRETATIONS

Soil information compiled in this report can provide valuable information to users other than agriculture. Engineers are interested in soil properties which effect the construction and maintenance of a variety of projects such as roads, airports, sewage-disposal systems and pipelines to name a few.

To provide this information subsoil samples were collected from sites chosen to represent the major series and parent materials recognized in the county. These samples were subjected to various standard engineering soil tests (15), the results of which are listed in Table 22.

Using information provided by profile and map unit descriptions, augmented by chemical and physical analysis, interpretation can be made for many engineering uses, as well as identifying engineering problems associated with certain soils. It should be emphasized, however, that the information has some limitations related to scale of mapping, presence of additional soil components with different properties within the map unit, and a certain allowable range of properties within each series. Therefore, on site investigations and additional analysis would be required to obtain more detail for specific interpretations. Despite these limitations soil survey data can be a useful guide in planning more detailed investigations.

TABLE 22. Engineering data for selected series in Warner County.

SERIES	PARENT MATERIAL	E.C. dS/m	Opt[1] moisture %	Max. dry[1] density kg/m^3	% PASSING SIEVE No. 4	% PASSING SIEVE No. 200	Liquid limit %	Plasticity limit %	Unified Class
Beazer	till	-	22	1950	87	51	31	12	CL
Chin	lacustrine	-	22	1600	100	91	36	21	CL
Coaldale	lacustrine	<3	30	1350	100	98	65	30	CH
Clarinda	till	-	16	1800	95	51	33	16	CL
Cradduck	till	<3	17	1700	89	67	35	18	CL
					(83-98)[2]	(58-78)[2]	(29-44)[2]	(16-21)[2]	
Cavendish	fluvial	-	-	-	100	12	NP	NP	SM-SC
Grudge	till	>5	16	1750	90	76	32	17	CL
Hegson	lacustro-till	-	28	1450	100	93	58	27	CH
Hemaruka	till	15	17	1800	90	87	36	17	CL
Klemengurt	lacustrine	11	22	1500	100	98	65	23	CH
Knight	glaciofluvial	-	-	-	95	3	NP	NP	SP
Kessler	fluvial	-	-	-	100	25	NP	NP	SM
Lethbridge	lacustrine	<1	15	1800	100	72	26	17	CL
Maleb	till	<5	15	1850	62	41	37	15	CL
Masinasin	till	<3	14	1900	94	66	31	16	CL
					(80-99)[2]	(47-98)[2]	(25-43)[2]	(14-20)[2]	
Purescape	till	<1	12	1750	97	70	38	17	CL
Rockford	ice-contact	<1	12	1950	93	41	25	14	SC
Sloughay	lacustrine	<1	30	1400	100	92	63	30	CH
Sprole	till	<1	18	1650	99	73	33	20	CL
Tempest	lacustrine	-	-	-	99	72	27	22	CL
Verburg	till	-	16	1750	92	67	28	17	CL
Wilda	till	-	15	1800	96	63	33	16	CL

[1] Standard Proctor tests for optimum moisture and maximum dry density were based on the correlation method outlined by Ring and Solberg (21) using the nomograph charts developed by the Highways Laboratory, Alberta Transportation.

[2] Ranges (minimum-maximum).

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APPENDICES

Appendix A: Analytical Methods

Most chemical and physical analyses were determined by the methods outlined by McKeague (17), except for the $CaCO_3$ equivalent which was determined using the method of Schollenberger (22). These results are presented on the following pages as part of the soil profile characterization. In addition, analyses were conducted to determine the general engineering properties of the soils in the county, by the methods outlined by Greenlee (15). The Unified classification is based on the method outlined in the PCA Soil Primer (20). Optimum moisture and maximum density were based on the correlation method outlined by Ring and Sallberg (21), using the nomograph charts developed by the Highways Laboratory, Alberta Transport. Results from these engineering tests have been included in the Engineering Interpretations section.

It is important to know the chemical and physical properties of soil as they are basic to soil classification and are also an indication of the soils performance capabilities. Following are some brief comments relative to the significance of the analyses conducted.

Reaction (pH). A measure of the intensity of soil acidity or alkalinity, which reflects the base status of the soil.

Nitrogen (N). Nitrogen is an important plant nutrient which is usually concentrated in the A horizon of soils in the form of decomposed organic matter. In virgin soil the nitrogen content can be directly related to the amount of organic matter and therefore to soil colors in the Ah horizon; darker colored Ah horizons have a higher nitrogen content than do lighter colored Ah horizons.

Organic Carbon (O.C.). Organic carbon provides an estimate of organic matter content in the soil.

Exchangeable Cations and Total Exchange Capacity (T.E.C.). The cation exchange capacity is important in the fertility of a soil. This capacity increases with increased clay and organic matter content and is less in sandy soils. A criterion used in the classification of Solonetzic soils is the ratio of exchangeable calcium to exchangeable sodium. A ratio of 10 or less is necessary for a a soil to be classified as belonging to the Solonetzic Order.

Calcium Carbonate Equivalent. This is a measure of the lime carbonate content of a soil.

Particle Size Distribution. This is a determination of the relative amounts of sand, silt and clay in a soil.

Electrical Conductivity (E.C.). This is an indication of the amount of water soluble salts in the soil. Weakly saline soils (E.C. 4-8 m S/cm) limit the growth of senstive crops. The growth of all crops is inhibited on moderately saline soils (E.C. 8-16 m S/cm) and only a few salt tolerant plants can survive on strongly saline soils (E.C. higher than 16 m S/cm).

Available Moisture. This is defined as the portion of soil moisture that can readily be absorbed by plant roots.

Appendix B. Detailed Soil Series Information.

BUNTON SERIES

Location: NW3, Twp 6, Rge 16, W4

Classification: Orthic Brown Chernozemic

Parent Material: Medium textured fluvial

Land Use: Rangeland

Profile Description

Horizon	Depth cm	
Ah	0- 14	Dark grayish brown (10YR 4/2 d); loam; 5% coarse fragments; weak to moderate, fine granular; laminated; friable; slightly hard; plentiful, very fine and fine, random roots; smooth, gradual boundary; 12-16 cm thick; neutral.
Bm	14- 28	Brown (10YR 5/3 d); loam; 5% coarse fragments; moderate, medium, prismatic and moderate, medium, subangular blocky; stratified; hard; plentiful, very fine and fine, vertical roots; clear, wavy boundary; 6-16 cm thick; neutral.
Ahb	28- 38	Dark brown (10YR 3.5/3); very dark grayish brown (10YR 3/2 m); loam; 5% coarse fragments; weak to moderate, medium prismatic; hard; plentiful, very fine and fine, vertical roots; smooth, gradual boundary; 2-11 cm thick; neutral.
Bmb	38- 52	Brown (10YR 5/3.5 d); sandy loam; 5% fragments; moderate, fine to medium, subangular blocky; hard; few vertical roots; smooth gradual boundary; 14-21 cm thick; neutral.
Ck1	53- 63	Yellowish brown (10YR 5/5 d); sandy loam; 5% coarse fragments; weak granular; hard; weakly calcareous; few, fine and very fine roots; smooth, abrupt boundary; 7-15 cm thick; neutral.
Ck2	63- 74	Pale brown (10YR 6/3 d); sandy loam; 5% coarse fragments; massive; slightly hard; weakly calcareous; few, very fine and fine roots; smooth, abrupt boundary; 5-13 cm thick.
Ck3	74-100	Yellowish brown (10YR 5/4 d); sandy loam; 10% coarse fragments; single grain; loose; weakly calcareous; few, fine, vertical roots; smooth, abrupt boundary; 23-28 cm thick.
Ck4	100-107	Pale brown (10YR 6/3 d); loamy sand; massive; soft; few, fine, vertical roots; weakly calcareous.

CHEMICAL ANALYSIS

Horizon	Depth cm	pH		N %	Org. C %	C/N	Exchange Cations me/100g				TEC* me/ 100g	CaCO$_3$ equiv. %	Elec. Cond. dS/m	Water Soluble Salts me/1				SSP* %	SAR*
		H$_2$O	CaCl$_2$				Na	K	Ca	Mg				Na	K	Ca	Mg		
Ah	0-14	6.6	6.8	0.44	3.33	8	0.3	1.4	14.6	4.3	20.9	-	-	-	-	-	-	-	-
Bm	14-28	7.2	7.0	0.11	1.15	10	0.3	1.0	10.7	3.6	14.4	-	-	-	-	-	-	-	-
Ahb	28-38	7.2	7.0	0.10	0.96	10	0.3	1.4	11.3	4.2	16.2	-	-	-	-	-	-	-	-
Bmb	38-52	7.4	7.2	0.08	0.79	10	0.3	1.1	10.1	4.1	12.7	0.2	-	-	-	-	-	-	-
Ck1	52-63	7.9	7.3	-	-	-	-	-	-	-	-	3	<1	-	-	-	-	-	-
Ck2	63-74	7.9	7.4	-	-	-	-	-	-	-	-	5	<1	-	-	-	-	-	-
Ck3	74-100	8.0	7.5	-	-	-	-	-	-	-	-	5	<1	-	-	-	-	-	-
Ck4	100-107	8.0	7.5	-	-	-	-	-	-	-	-	3	<1	-	-	-	-	-	-

PHYSICAL ANALYSIS

Horizon	Particle Size Distribution %									Text. Class	Moisture Status %		AWC* %	Bulk Density g/cc	Hydr. Cond. cm/hr
	>2mm	vc	c	m	f	vf	S	Si	C		1/3 atm	15 atm			
Ah	-	-	-	-	-	-	30	37	25	L	31	22	9	-	-
Bm	-	-	-	-	-	-	47	34	19	L	17	11	6	-	-
Ahb	-	-	-	-	-	-	46	32	22	L	-	-	-	-	-
BMb	-	-	-	-	-	-	55	28	17	SL	-	-	-	-	-
Ck1	-	-	-	-	-	-	71	19	10	SL	-	-	-	-	-
Ck2	-	-	-	-	-	-	73	17	10	SL	-	-	-	-	-
Ck3	-	-	-	-	-	-	60	30	10	SL	-	-	-	-	-
Ck4	-	-	-	-	-	-	83	11	6	LS	-	-	-	-	-

*TEC = total exchange capacity; SSP = soluble sodium percentage; SAR = sodium absorption rates; AWC = available water holding capacity.

BEAZER SERIES

Location: NW9, Twp 4, Rge 20, W4

Classification: Orthic Black Chernozemic

Parent Material: Moderately fine to medium textured, moderately calcareous till

Land Use: Road allowance

Profile Description

Horizon	Depth cm	
Ah1*	0-7	Very dark grayish brown (10YR 3/2 m); clay loam; drift; weak to moderate medium granular; loose; abundant, very fine and fine, random roots; clear, smooth boundary; 7-8 cm thick; neutral.
Ah2	7-17	Very dark grayish brown (10YR 2.5/2 m); clay loam; very weak, fine, subangular blocky; loose; abundant, very fine and fine, random roots; clear, smooth boundary; 10-14 cm thick; neutral.
Bm	17-45	Dark brown (10YR 3.5/3 d); clay loam; moderate, fine to medium, angular block; slightly hard; plentiful, very fine and fine, vertical root; gradual, wavy boundary; 25-32 cm thick; slightly acid.
BC	45-68	Dark brown (10YR 4/3 d); loam; moderate, medium, subanguglar blocky; plentiful, very fine to fine, vertical roots; abrupt, wavy boundary; 15-22 cm thick; neutral.
Ck1	68-96	Pale brown (10YR 6/3 d); clay loam; massive; slightly hard; moderately calcareous; gradual, wavy boundary; 12-28 cm thick.
Ck2	96-110+	Dark yellowish brown (10YR 4/3.5 m); clay loam; massive; friable; moderately calcareous.

*The Ah1 is drift.

CHEMICAL ANALYSIS

Horizon	Depth cm	pH H₂O	pH CaCl₂	N %	Org. C %	C:N	Exchange Cations me/100g Na	K	Ca	Mg	TEC* me/100g	CaCO₃ equiv. %	Elec. Cond. dS/m	Water Soluble Salts me/l Na	K	Ca	Mg	SSP* %	SAR*
Ah1	0- 7	7.5	7.2	0.48	6.16	13	0.2	2.9	28.0	4.4	35.9	1.0	-	-	-	-	-	-	-
Ah2	7- 17	7.2	6.8	0.40	4.58	11	0.2	2.5	19.1	8.4	33.9	-	-	-	-	-	-	-	-
Bm	17- 45	6.5	6.3	-	1.47	-	0.0	0.8	12.7	8.9	25.9	-	-	-	-	-	-	-	-
BC	45- 68	7.3	7.0	-	-	-	0.1	0.6	14.1	7.8	23.0	0.3	-	-	-	-	-	-	-
Ck1	68- 96	7.9	7.6	-	-	-	-	-	-	-	-	11	<1	-	-	-	-	-	-
Ck2	96- 0	8.0	7.7	-	-	-	-	-	-	-	-	13	<1	-	-	-	-	-	-

PHYSICAL ANALYSIS

Horizon	Particle Size Distribution % >2mm	vc	c	m	f	vf	S	Si	C	Text. Class	Moisture Status % 1/3 atm	15 atm	AWC* %	Bulk Density g/cc	Hydr. Cond. cm/hr
Ah1	<5	0	3	8	14	12	37	25	28	CL	35	28	7	-	-
Ah2	<5	0	2	6	14	9	31	41	28	CL	30	24	6	-	-
Bm	<5	0	3	8	15	8	34	31	35	CL	22	16	6	-	-
BC	<5	1	3	8	16	8	37	36	27	L	21	15	6	-	-
Ck1	<5	0	3	7	15	8	33	30	28	CL	-	-	-	-	-
Ck2	<5	0	2	7	16	9	34	38	28	CL	22	13	9	-	-

*TEC = total exchange capacity; SSP = soluble sodium percentage; SAR = sodium absoprtion rates; AWC = available water holding capacity.

COALDALE SERIES

Location: NC22, Twp 6, Rge 21, W4

Classification: Orthic Dark Brown Chernozemic

Parent Material: Moderately fine to fine lacustrine

Land Use: Cropland (irrigated)

Profile Description

Horizon	Depth cm	
Ap1*	0-15	Very dark grayish brown (10YR 3/2 m), dark grayish brown (10YR 4/2 d); silty clay loam; moderate, medium, subangular blocky and moderate to strong, coarse granular; very hard; platic; clear, wavy boundary; 13-15 cm thick; mildly alkaline.
Ap2	15-26	Dark brown (10YR 3/3 m); clay loam; weak, very coarse, subangular blocky and moderate, fine to medium, subangular blocky, hard; plastic; clear, wavy boundary; 8-16 cm thick; mildly alkaline.
Bm1	26-38	Dark yellowish brown (10YR 3/4 m); silty clay; modeate, fine to medium, subangular blocky, firm; plastic; clear, wavy boundary; 12-21 cm thick; mildly alkaline.
Bm2	38-47	Dark brown (10YR 4/3 m); silty clay loam; weak to moderate, coarse prismatic and weak, medium, angular blocky, friable; plastic; gradual, smooth boundary; 9-12 cm thick; mildly alkaline.
Cca	47-84	Dark grayish brown (10YR 4.5/2 m); clay loam; massive; friable; plastic; modeately calcareous; gradual, wavy boundary; 32-40 cm thick.
Ck	84-100	Dark Brown (10YR 4/3 m) silty clay loam; massive; friable; plastic; weakly calcareous.

*This profile is in an irrigated area. The A horizon is thicker than normal and the solum is very weakly calcareous.

CHEMICAL ANALYSIS

Horizon	Depth cm	pH		N %	Org C %	C/N	Exchange Cations me/100g				TEC* me/100g	$CaCO_3$ equiv %	Elec Cond dS/m	Water Soluble Salts me/l				SSP* %	SAR*
		H_2O	$CaCl_2$				Na	K	Ca	Mg				Na	K	Ca	Mg		
Ap1	0-15	7.6	7.4	0.23	2.03	9	-	-	-	-	24.2	0.4	2	-	-	-	-	-	-
Ap2	15-26	7.7	7.5	-	1.91	-	-	-	-	-	22.1	0.3	2	-	-	-	-	-	-
Bm1	26-38	7.7	7.4	-	1.04	-	-	-	-	-	27.4	-	1	-	-	-	-	-	-
Bm2	38-47	7.8	7.4	-	0.78	-	-	-	-	-	21.5	0.4	<1	-	-	-	-	-	-
Cca	47-84	8.0	7.5	-	-	-	-	-	-	-	17.7	15	<1	-	-	-	-	-	-

PHYSICAL ANALYSIS

Horizon	Particle Size Distribution %									Text. Class	Moisture Status %		AWC* %	Bulk Density g/cc	Hydr Cond cm/hr
	>2mm	vc	c	m	f	vf	S	Si	C		1/3 atm	15 atm			
Ap1	0	0	0	2	9	8	19	48	33	SiCL	30	17	13	-	-
Ap2	0	0	0	3	10	10	23	43	34	CL	29	18	11	-	-
Bm1	0	0	0	2	8	7	27	42	41	SiC	31	20	11	-	-
Bm2	0	0	0	1	5	10	16	50	34	SiCL	26	17	9	-	-
Cca	0	0	0	3	16	14	33	36	31	CL	-	-	-	-	-

*TEC = total exchange capacity; SSP = soluble sodium percentage; SAR = sodium absorption rates; AWC = available water holding capacity.

CRADDUCK SERIES

Location: NW15, Twp 4, Rge 18, W4

Classification: Orthic Dark Brown Chernozemic

Parent Material: Medium to moderately fine textured, moderately calcareous till

Land Use: Cropland

Profile Description

Horizon	Depth Cm	
Ap	0-17	Very dark, grayish brown (10YR 3/2 m); dark, grayish brown (10YR 4/2 d); loam; moderately, fine, subangular blocky; very friable; clear, smooth boundary; 13-18 cm thick; slightly acid.
Bm	17-31	Dark Brown (7.5YR 3/2 m); dark yellowish brown (10YR 3/4 d); clay loam; moderate, fine to medium, prismatic and moderate, coarse subangular blocky; friable; clear, wavy boundary; 12-16 cm thick; slightly acid.
Cca	31-58	Grayish brown to light olive brown (2.5Y 5/3 m); clay loam; massive; very friable; strongly calcareous; gradual, wavy boundary; 25-29 cm thick.
Ck	58-100+	Dark grayish brown (2.5Y 4/2 m); clay loam; massive; very friable; moderately calcareous. 2% coarse fragments throughout profile, some larger than 10 cm.

CHEMICAL ANALYSIS

Horizon	Depth cm	pH H₂O	pH CaCl₂	N %	Org C %	C:N	Exchange Cations me/100g Na	K	Ca	Mg	TEC* me/100g	CaCO₃ equiv %	Elec Cond dS/m	Water Soluble Salts me/l Na	K	Ca	Mg	SSP* %	SAR*
Ap	0-17	6.8	6.5	0.20	2.32	12	0.1	2.0	12.7	2.4	22.3	-	-	-	-	-	-	-	-
Bm	17-31	6.8	6.4	-	1.06	-	0.1	1.1	14.7	3.3	25.3	-	-	-	-	-	-	-	-
Cca	31-58	7.4	7.2	-	-	-	0.1	0.3	38.3	6.1	19.7	17	-	-	-	-	-	-	-
Ck	58-100	7.6	7.5	-	-	-	-	-	-	-	14.4	14	3	36.6	0.2	5.9	10.9	68	13

PHYSICAL ANALYSIS

Horizon	>2mm	Particle Size Distribution % vc	c	m	f	vf	S	Si	C	Text Class	Moisture Status % 1/3 atm	15 atm	AWC* %	Bulk Density g/cc	Hydr Cond cm/hr
Ap	4	0	1	8	19	10	38	36	26	L	23	13	10	1.39	-
Bm	2	0	3	11	13	5	32	36	32	CL	23	13	10	-	-
Cca	4	0	4	8	10	6	28	40	32	CL	-	-	-	-	-
Ck	2	0	1	6	11	7	25	40	35	CL	24	12	12	1.52	1.8

*Tec = total exchange capacity; SSP = soluble sodium percentage; SAR = sodium absorption rates; AWC = available water holding capacity

CRANFORD SERIES

Location: SW26, Twp 7, Rge 17, W4

Classification: Orthic Brown Chernozemic

Parent Material: Medium to moderately fine textured lacustrine veneer over till

Land Use: Cropland

Profile Description

Horizon	Depth cm	
Ap*	0-22	Dark grayish brown (10YR 4/2.5 m), very dark grayish brown to dark brown (10YR 3/2.5 d); silt loam; weak to moderate, fine to medium subangular blocky and weak, very fine to fine granular; very friable; slightly plastic; abundant, very fine and fine, random roots; smooth, gradual horizon boundary; 20-25 cm thick; neutral.
Bm	22-42	Dark brown (10YR 4/3 m); brown (10YR 5/3 d); silty clay loam; moderate, fine to medium, prismatic and weak moderate, medium, subangular blocky; friable; slightly sticky; slightly plastic; abundant, very fine and fine, vertical roots; smooth, clear boundary; 18-25 cm thick; mildly alkalinie.
Cca	42-75	Pale brown (10YR 6/3 m); silt loam; weak fine, subangular blocky; friable; slightly sticky; plastic; plentiful, very fine and fine, vertical roots; strongly calcareous; smooth, gradual boundary; 30-38 cm thick.
IICk1	75-105	Dark grayish brown (10YR 4/2 m), grayish brown (10YR 5/2 d), 5% coarse fragments; clay loam; massive and medium to coarse, subangular blocky; friable; sticky; plastic; plentiful, very fine and fine vertical roots, moderately calcareous; smooth, gradual boundary; 30-25 thick.
IICk2	105-150	Very dark grayish brown (10YR 3/2 m), grayish brown (10YR d), 5% coarse fragments; clay loam; massive and medium to coarse, subangular blocky; friable; sticky; plastic; moderately calcareous; few, very fine, vetical roots.

*Ap is thicker than normal probably due to drifting.

CHEMICAL ANALYSIS

Horizon	Depth cm	pH H_2O	pH $CaCl_2$	N %	Org C %	C:N	Exchange Cations me/100g Na	K	Ca	Mg	TEC* me/100g	$CaCO_3$ equiv %	Elec. Cond. dS/m	Water Soluble Salts me/l Na	K	Ca	Mg	SSP* %	SAR*
Ah	0-22	7.5	7.3	0.32	2.47	8	0.4	2.2	20.0	3.3	22.7	0.3	-	-	-	-	-	-	-
Bm	22-42	7.5	7.4	-	1.84	-	0.1	1.0	16.8	4.1	21.2	0.2	-	-	-	-	-	-	-
Cca	42-75	7.9	7.6	-	-	-	-	-	-	-	-	22	<1	-	-	-	-	-	-
IICk1	75-105	8.3	7.5	-	-	-	-	-	-	-	-	9	<1	-	-	-	-	-	-
IICk2	105-150	8.1	7.5	-	-	-	-	-	-	-	-	6	<1	-	-	-	-	-	-

PHYSICAL ANALYSIS

Horizon	Particle Size Distribution % >2mm	vc	c	m	f	vf	S	Si	C	Text. Class	Moisture Status % 1/3 atm	15 atm	AWC* %	Bulk Density g/cc	Hydr Cond cm/hr
Ah	<1	-	-	-	-	-	21	53	26	SiL	27	18	9	-	-
Bm	<1	-	-	-	-	-	18	54	28	SiCL	24	16	8	-	-
Cca	<1	-	-	-	-	-	7	67	26	SiL	-	-	-	-	-
IICk1	5	-	-	-	-	-	39	33	28	CL	-	-	-	-	-
IICk2	5	-	-	-	-	-	42	30	28	CL	-	-	-	-	-

*TEC = total exchange capacity; SSP = soluble sodium percentage; SAR = sodium absorption rates; AWC = available water holding capacity

GRUDGE SERIES

Location: NE31, Twp 2, Rge 17, W4

Classification: Dark Brown Solodized Solonetz

Parent Material: Medium to moderately fine textured, moderately saline, moderately calcareous till

Land Use: Rangeland

Profile Description

Horizon	Depth cm	
Ah*	0-2	Dark grayish brown (10YR 4/2 d); silt loam; weak, fine granular; soft; abundant, very fine, random roots, wavy boundry; 1-3 cm thick.
Ae	2-7	Light brownish gray (10YR 6/2 d); silt loam; weak to moderate, fine to medium, subangular blocky and weak to moderate, medium platy; soft, plentiful, very fine and fine, random roots; clear, wavy boundary; 4-7 cm thick.
Bnt	7-30	Very dark, grayish brown (10YR 3/2 d); heavy clay; strong, coarse columnar, very hard, plastic, many, moderately thick clay films on ped faces; few, fine, vertical roots; clear, wavy boundary; 23-25 cm thick; neutral.
BCs	30-40	Dark brown (10YR 4/3 d); clay, strong, medium to coarse prismatic and moderate, medium angular blocky; very hard; plastic; weakly saline; few, fine vertical roots; gradual wavy boundary; 7-14 cm thick; mildly alkaline.
Csa1	40-51	Yellowish brown (10YR 5/4 d); silty clay loam, weak, medium to coarse, subangular blocky; hard slightly plastic; weakly saline; very few, fine, vertical roots, clear, wavy boundary; 19-26 cm thick; mildly alkaline.
Csa2	51-70	Dark brown (10YR 3/3 d); silty clay loam; weak, medium, prismatic; hard; plastic; moderately saline, weakly calcareous, very few, fine, vertical roots; gradual, wavy boundary; 19-26 cm thick
Cks	70-100+	Pale brown (10YR 6/3 d); loam; massive; very hard; plastic; weakly saline, strongly calcareous.

*This A horizon thickness is typical of eroded areas.

CHEMICAL ANALYSIS

Horizon	Depth cm	pH H_2O	pH $CaCl_2$	N %	Org C %	C/N	Exchange Cations me/100g Na	K	Ca	Mg	TEC* me/100g	$CaCO_3$ equiv %	Elec Cond dS/m	Water Soluble Salts me/l Na	K	Ca	Mg	SSP* %	SAR*
Ae	2- 7	7.1	6.6	0.17	1.69	10	1.1	0.7	6.0	2.6	12.1	-	1	-	-	-	-	-	-
Bnt	7- 30	7.6	7.3	-	1.66	-	8.2	1.4	17.0	16.0	44.5	-	2	15.7	0.1	0.8	0.6	92	19
Bcs	30- 40	7.6	7.5	-	-	-	-	-	-	-	40.9	0.3	7	66.6	0.4	22.5	25.8	58	14
Csa1	40- 51	7.7	7.6	-	-	-	-	-	-	-	28.0	0.2	8	72.2	0.5	21.3	34.5	56	14
Csa2	51- 70	7.7	7.6	-	-	-	-	-	-	-	27.4	0.8	9	86.6	0.5	19.3	53.0	54	14
Cks	70-110	8.2	7.8	-	-	-	-	-	-	-	14.5	21	5	54.4	0.2	2.4	12.2	79	20

PHYSICAL ANALYSIS

Horizon	Particle Size Distribution % >2mm	vc	c	m	f	vf	S	Si	C	Text Class	Moisture Status % 1/3 atm	15 atm	AWC* %	Bulk Density g/cc	Hydr Cond cm/hr
Ae	-	-	-	-	-	-	18	61	21	SiL	25	9	16	-	-
Bnt	-	-	-	-	-	-	8	29	63	HC	53	31	22	-	-
Bcs	-	-	-	-	-	-	9	35	56	C	43	23	20	-	-
Csa1	-	-	-	-	-	-	18	53	29	SiCL	28	17	11	-	-
Csa2	1	-	-	-	-	-	14	55	31	SiCL	28	14	14	-	-
Cks	1	-	-	-	-	-	27	48	25	L	26	11	15	-	-

*TEC = total exchange capacity; SSP = soluble sodium percentage; SAR = sodium absorption rates; AWC = available water holding capacity

KESSLER SERIES

Location: WC31, Twp 6, Rge 20, W4

Classification: Orthic Dark Brown Chernozemic

Parent Material: Moderately coarse fluvial

Land Use: Cropland (irrigated)

Profile Description

Horizon	Depth cm	
Ap	0-17	Dark gray to dark grayish brown (10YR 4/1.5 d); fine sandy loam; very weak, medium to coarse subangular blocky; very friable; slightly hard; nonplastic; plentiful, micro and very fine, random roots, clear, smooth boundary, 14-18 cm thick, neutral
BM1	17-57	Brown (10YR 4/3 m); fine sandy loam; very weak, medium prismatic and weak, fine subangular blocky; firm, hard, nonplastic, abundant, fine and medium vertical roots; clear, smooth boundary, 38-42 cm thick, neutral
Bm2	57-80	Dark yellowish brown (10YR 3.5/4 m); fine sandy loam; massive; hard; nonplatic; few, very fine and fine vertical roots; gradual, smooth boundary, 20-25 cm thick; slightly acid
Bm3	80-100	Dark yellowish brown (10YR 4.5/4.5 m); fine sandy loam; massive; firm; hard; nonplastic; few, fine, vertical roots, clear, smooth boundary; 18-20 cm thick, neutral
Cca	100-115+	Yellowish brown (10YR 5/4.5 m); fine sandy loam; massive; firm; hard; nonplastic, moderately calcareous

CHEMICAL ANALYSIS

Horizon	Depth cm	pH H₂O	pH CaCl₂	N %	Org C %	C/N	Exchange Cations me/100g Na	K	Ca	Mg	TEC* me/100g	CaCO₃ equiv %	Elec Cond dS/m	Water Soluble Salts me/l Na	K	Ca	Mg	SSP* %	SAR*
Ap	0-17	7.4	7.0	0.16	1.72	11	0.0	2.2	10.9	2.2	12.7								
Bm1	17-57	7.2	7.0		1.12		0.0	1.2	12.2	2.5	14.4								
Bm2	57-80	6.3	6.3		1.04		0.0	0.3	10.3	2.3	12.1								
Bm3	80-100	6.8	6.6		0.55		0.0	0.3	13.6	2.9	12.7	0.5							
Cca	100-115	7.2	6.9				0.0	0.2	33.0	2.9	5.8	7							

PHYSICAL ANALYSIS

Horizon	Particle Size Distribution % 2mm	vc	c	m	f	vf	S	Si	C	Text Class	Moisture Status % 1/3 atm	15 atm	AWC* %	Bulk Density g/cc	Hydr Cond cm/hr
Ap		0	0	3	49	22	69	13	18	FSL	14	9	5		
Bm1		0	0	2	40	22	64	18	18	FSL	12	7	5		
Bm2							67	15	18	FSL	13	9	4		
Bm3		0	0	2	51	22	76	7	17	FSL	10	8	2		
Cda							75	7	18	FSL	11	8	3		

*TEC – total exchange capacity, SSP – soluble sodium percentage, SAR – sodium absorption rates, AWC – available water holding capacity

LETHBRIDGE SERIES

Location: SE26, Twp 6, Rge 21, W4

Classification: Orthic Dark Brown Chernozemic

Parent Material: Medium to moderately fine textured lacustrine

Land Use: Cropland (irrigated)

Profile Description

Horizon	Depth cm	
Ap1*	0-12	Very dark grayish brown (10YR 3/2.5 m); dark grayish brown (10YR 4/2.5 d); loam; weak to moderate, fine to medium, subangular blocky and weak to moderate, fine, granular; firm; abrupt, smooth boundary, 10-13 cm thick; neutral
Ap2	12-20	Very dark brown (10YR 3/2.5 m); clay loam; weak to moderate, coarse platy; friable; clear, smooth boundary, 6-8 cm thick; neutral
Bm1	20-30	Very dark grayish brown (10YR 3/2 m); clay loam; moderate, fine, subangular blocky; firm; clear, smooth boundary, 9-11 cm thick; neutral
Bm2	30-46	Dark yellowish brown (10YR 4/4m); clay loam; moderate, medium prismatic and weak, fine to medium, angular blocky; friable; clear, wavy boundary; 15-18 cm thick; neutral
Ck1	46-80	Yellowish brown (10YR 5.5/3.5 m); loam; massive; very friable; modeately clacareous; gradual, wavy boundary; 30-36 cm thick
Ck2	80-100+	Yellowish brown (10YR 5.5/3.5 m); loam; massive; very friable; moderately calcareous.

*A horizon thicker than usual because of land levelling

CHEMICAL ANALYSIS

Horizon	Depth cm	pH		N	Org C	C/N	Exchange Cations me/100g				TEC* me/100g	CaCO$_3$ equiv %	Elec Cond dS/m	Water Soluble Salts me/l				SSP* %	SAR*
		H$_2$O	CaCl$_2$	%	%		Na	K	Ca	Mg				Na	K	Ca	Mg		
Ap1	0-12	7.5	7.2	0.15	1.59	11					19.7	0.2	1						
Ap2	12-20	7.5	7.2		1.27						19.4	0.2	1						
AB	20-30	7.7	7.2		1.30						19.8		1						
Bm	30-46	7.5	7.3		0.89						15.6	0.1	1						
Ck1	46-80	7.5	7.4								10.2	12	2						
Ck2	80-100	8.0	7.5									16	1						

PHYSICAL ANALYSIS

Horizon	Particle Size Distribution %									Text Class	Moisture Status %		AWC* %	Bulk Density g/cc	Hydr Cond cm/hr
	[illegible]	vc	c	m	f	vf	S	Si	C		1/3 atm	15 atm			
Ap1	0	0	0	4	22	15	41	36	23	L	21	11	10		
Ap2	0	0	0	5	23	15	43	29	28	CL	19	11	8		
AB	0	0	0	4	19	16	39	32	29	CL	21	13	8		
Bm	0	0	0	3	16	13	32	33	35	CL	23	16	7		
Ck1	0	0	0	2	17	20	40	39	21	L	18	10	8		
Ck2	0	0	0	2	13	26	41	37	22	L	13	8	5		

*TEC - total exchange capacity, SSP - soluble sodium percentage, SAR - sodium abropstion rates, AWC - available water holding capacity

LILYDALE SERIES

Location SE9, Twp 6, Rge 18, W4

Classification Orthic Dark Brown Chernozemic Saline Phase

Parent Material Medium to moderately fine lacustrine

Land Use Abandoned farmland

Profile Description

Horizon	Depth cm	
Ahsa1	0-10	Very dark grayish brown (10YR 3/2 m), dark grayish brown (10YR 4/2 d), silt loam, weak, medium, subangular blocky to weak, fine, granular; very friable, slightly sticky; slightly plastic, strongly saline, abundant, fine, random roots, smooth, clear boundary, 9-11 cm thick
Ahsa2	10-16	Very dark grayish brown (10YR 3/2 m), silt loam, weak, medium subangular blocky to fine granular, very friable, slightly sticky, slightly plastic, strongly saline, abundant, fine random roots, smooth, abrupt boundary, 5-7 cm thick
Bmsa1	16-35	Dark brown (10YR 3/3 m), silt loam, weak, fine to medium, prismatic and weak, fine to medium, subangular blocky, friable, slightly sticky, slightly plastic consistence, strongly saline, plentiful, very fine, vertical, roots, gradual, wavy boundary, 19-21 cm thick
Bmsa2	35-40	Very dark grayish brown (10YR 3/2.5 m), silty clay loam, very weak, fine to medium, prismatic and weak, fine to medium, subangular blocky; friable, slightly plastic, slightly sticky, strongly saline, plentiful, very fine, vertical roots, clear, wavy boundary, 13-17 cm thick
Cksa1	50-75	Brown (10YR 4.5/3 m), silt loam, massive, friable, slightly sticky, slightly plastic, strongly saline, strongly calcareous, very few, very fine, vertical roots, smooth, abrupt boundary, 23-29 cm thick
Cksa2	75-90	Brown (10YR 5/3 m), loam, few, faint mottles, weak, medium to coarse, prismatic, friable, sticky, plastic, moderately saline, strongly calcareous, smooth abrupt boundary, 14-16 cm thick
Cksa3	75-120	Brown (10YR 5/3 m), loam, few, faint mottles, massive, friable, slightly sticky, slightly plastic, moderately saline, strongly calcareous, smooth, abrupt boundary

Note: Not all Lilydale is as saline as this profile.

CHEMICAL ANALYSIS

Horizon	Depth cm	pH H₂O	pH CaCl	N %	Org C %	C/N	Exchange Cations me/100g Na	K	Ca	Mg	TEC* me/100g	CaCO₃ equiv %	Elec Cond dS/m	Water Soluble Salts me/l Na	K	Ca	Mg	SSP* %	SAR*
Ahsa1	0-10	7.7	7.1	0.33	2.91	9						0.4	25	487.1	2.9	13.5	93.6	82	67
Ahsa2	10-16	7.7	7.1	0.20	1.96	8						0.2	25	521.7	0.9	20.1	110.2	80	65
Bmsa1	16-35	7.6	7.1		1.03								22	495.6	0.3	18.0	99.8	81	65
Bmsa2	35-50	7.7	7.1		0.94								24	534.8	0.3	12.9	104.0	82	70
Cksa1	50-75	7.8	7.2		0.94							16							
Cksa2	75-90	8.2	8.1									19							
Cksa3	90-120	8.2	8.4									16	15	282.6	0.3	15.5	60.3	79	46
Csk	120-150	8.1	8.0									18	8	200.0	0.3	6.2	18.9	89	56

PHYSICAL ANALYSIS

Horizon	Particle Size Distribution % 2mm	vc	c	m	f	vf	S	Si	C	Text Class	Moisture Status % 1/3 atm	15 atm	AWC* %	Bulk Density g/cc	Hydr Cond cm/hr
Ahsa1	0						18	58	24	SiL					
Ahsa2	0						17	57	26	SiL	30	16	14	1.25	
Bmsa1	0						21	52	27	SiL	26	13	13	1.33	
Bmsa2	0						17	53	30	SiCL					
Cksa1	0						7	68	25	SiL	24	12	12		
Cksa2	0						35	39	26	L	22	11	11		
Cksa3	0						38	38	24	L					
Csk	0						8	63	29	SiCL	28	18	10		

*TEC = total exchange capacity, SSP = soluble sodium percentage, SAR = sodium absorption rates, AWC = available water holding capacity

MALEB SERIES

Location: NE24, Twp 6, Rge 17, W4

Classification: Orthic Brown Chernozemic

Parent Material: Moderately fine to medium textured, weakly calcareous, weakly saline till

Land Use: Cropland

Profile Description

Horizon	Depth cm	
Ap	0-14	Brown (10YR 5/3 d); loam, 5% coarse fragments; moderate, fine to medium granular; loose; abundant, fine, random, roots; smooth, clear boundary; 10-15 cm thick; neutral.
Bm	14-29	Dark brown (10YR 4/3 d); clay loam; 5%, gravelly and cobbly, coarse fragments; weak to moderate, fine, prismatic and moderate, medium, subangular blocky soft; plentiful, fine, vertical, exped roots, smooth, clear boundary; 13-19 cm thick, neutral.
Cca	29-62	Light gray (10YR 7/2 d) and brown (10YR 5.5/3 d); loam 5%, gravelly and cobbly, coarse fragments; moderate to strong, fine, prismatic and moderate to strong, medium, subangular, blocky; hard; moderately calcareous; plentiful, very fine, vertical, exped roots; gradual, wavy boundary; 30-35 cm thick.
Cks1	62-106	Dark yellowish brown (10YR 3.5/4 d); loam, 5% gravelly and cobbly, coarse fragment; massive, friable, weakly calcareous; weakly saline; few, very fine, random, inped roots; gradual wavy boundary; 40-50 cm thick.
Cks2	106-140	Dark yellowish brown (10YR 3.5/4 m); loam; 5% gravelly and cobbly, coarse fragments, massive; friable, weakly calcareous, weakly saline.

CHEMICAL ANALYSIS

Horizon	Depth cm	pH		N %	Org C %	C/N	Exchange Cations me/100g				TEC* me/100g	$CaCO_3$ equiv %	Elec Cond dS/m	Water Soluble Salts me/l				SSP* %	SAR*
		H_2O	$CaCl_2$				Na	K	Ca	Mg				Na	K	Ca	Mg		
Ah	0-14	7.6	7.3	0.17	1.84	11													
Bm	14-29	8.0	7.4		1.30							0.6							
Cca	29-62	8.0	7.8									0.2							
Csk1	62-106	8.0	7.5									8							
Csk2	106-140	8.1	8.1									5	5	62.2	1.4	10.7	20.4	66	16
												4	5	37.8	0.9	8.0	20.6	56	10

PHYSICAL ANALYSIS

Horizon	Particle Size Distribution %									Text Class	Moisture Status %		AWC* %	Bulk Density g/cc	Hydr Cond cm/hr
	<2mm	vc	c	m	f	vf	S	Si	C		1/3 atm	15 atm			
Ah	< 5						32	40	28	CL	25	16	9		
Bm	< 5						39	33	28	CL	23	16	7		
Cca	< 5						36	37	27	L					
Csk1	< 5						38	36	26	L	25	16	9		
Csk2	< 5						38	35	27	L					

*TEC = total exchange capacity, SSP = soluble sodium percentage, SAR = sodium absorption rates, AWC = available water holding capacity

MASINASIN SERIES

Location: SE7, Twp 2, Rge 14, W4

Classification: Orthic Brown Chernozemic

Parent Material: Medium to moderately fine textured, moderately calcareous till

Land Use: Rangeland

Profile Description

Horizon	Depth cm	
Ahk	0-11	Dark brown (10YR 3/3 m); loam; weak fine to medium, subangular blocky to weak, fine to medium granular; very friable; slightly plastic; abundant, very fine, random roots; abrupt wavy boundary; 9-13 cm thick; mildly alkaline.
Bm	11-21	Brown (10YR 4/3 m); loam; weak to moderate, fine prismatic and weak to moderate, fine, subangular blocky; friable; slightly plastic; plentiful very fine vertical roots; abrupt irregular boundary; 6-19 cm thick; mildly alkaline.
Cca1	21-55	Pale brown (10YR 6/3 m); loam; 5% cobbly coarse fragments; weak to moderate, fine to medium, prismatic and weak to moderate, medium to coarse, subangular blocky; slightly hard; slightly plastic; moderately calcareous; few, very fine, vertical roots; gradual, wavy, boundary; 23-27 cm thick.
Cca2	55-120	Brown (10YR 5/3 m); loam; 5% cobbly coarse fragments; massive; soft; plastic; strongly calcareous; very few, very fine, vertical roots; gradual, wavy boundary; 35-47 thick.
Ck	120+	Light olive brown (2.5Y 5/3 m); loam; 5% cobbly coarse fragments; massive; friable; plastic; moderately calcareous.

CHEMICAL ANALYSIS

Horizon	Depth cm	pH H₂O	pH CaCl₂	N %	Org C %	C/N	Exchange Cations me/100g Na	K	Ca	Mg	TEC* me/100g	CaCO₃ equiv %	Elec Cond dS/m	Water Soluble Salts me/l Na	K	Ca	Mg	SSP* %	SAR*
Ahk	0-11	7.9	7.7	0.10	1.17	12	-	-	-	-	-	2	-	-	-	-	-	-	-
Bm	11-21	7.9	7.7	-	1.22	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Cca1	21-55	8.0	7.8	-	-	-	-	-	-	-	-	15	<1	-	-	-	-	-	-
Cca2	55-120	8.4	8.2	-	-	-	-	-	-	-	-	16	<1	-	-	-	-	-	-
Ck	120-135	7.8	7.8	-	-	-	-	-	-	-	-	11	3	-	-	-	-	-	-

PHYSICAL ANALYSIS

Horizon	Particle Size Distribution % >2mm	vc	c	m	f	vf	S	Si	C	Text Class	Moisture Status % 1/3 atm	15 atm	AWC* %	Bulk Density g/cc	Hydr Cond cm/hr
Ahk	2	-	-	-	-	-	37	38	25	L	20	13	7	-	-
Bm	5	-	-	-	-	-	37	34	29	CL	21	15	6	-	-
Cca1	5	-	-	-	-	-	30	44	26	L	22	13	9	-	-
Cca2	5	-	-	-	-	-	31	44	25	L	-	-	-	1.51	0.2

*TEC = total exchange capacity; SSP = soluble sodium percentage; SAR = sodium absorption rates; AWC = available water holding capacity

PURESCAPE SERIES

Location: SW2, Twp 3, Rge 19, W4

Classification: Orthic Dark Brown Chernozemic

Parent Material: Moderately fine to medium textured, moderately calcareous till

Land Use: Rangeland

Profile Description

Horizon	Depth cm	
Ah	0-13	Very dark brown (10YR 3/2 m); dark brown (10YR 4/2 d); loam; weak, very coarse, subangular blocky to moderate, coarse granular; slightly hard; slightly plastic; plentiful, very fine and fine, random roots; clear, irregular boundary; 10-15 cm thick; neutral.
Bm	13-40	Dark brown (10YR 3/3m, 10Y R 4/3d); clay loam; moderate to strong, medium, prismatic and moderate to strong, medium, angular blocky; hard; plastic; few, fine, vertical roots; clear, wavy boundary; 25-32 cm thick; neutral.
Ck1	40-57	Grayish brown (10YR 5/2 m), brown (10YR 5/3 d); loam, weak to moderate, medium, subangular blocky; hard, plastic; moderately calcareous; few, fine, vertical roots; gradual, wavy boundary; 36-45 cm thick.
Ck2	57-93	Grayish brown (2.5Y 5/2 m); pale brown (10YR 6/3 d); clay loam; 5% gravelly, coarse fragments; weak, coarse, subangular blocky; hard; plastic; moderately calcareous; very few, fine vertical roots; gradual, wavy boundary; 36-45 cm thick.
Ck3	93-120 +	Dark grayish brown (2.5Y 4/2 m); clay loam; 5% gravelly, coarse fragments, massive; friable; plastic; moderately calcareous.

CHEMICAL ANALYSIS

Horizon	Depth cm	pH H₂O	pH CaCl₂	N %	Org C %	C/N	Exchange Cations me/100g Na	K	Ca	Mg	TEC* me/100g	CaCO₃ equiv %	Elec Cond dS/m	Water Soluble Salts me/l Na	K	Ca	Mg	SSP* %	SAR*
Ah	0- 13	7.3	6.9	0.25	2.26	9	0.0	1.1	14.2	5.8	26.2	-	-	-	-	-	-	-	-
Bm	13- 40	7.2	6.8	-	1.43	-	0.3	0.7	16.8	5.3	27.3	-	-	-	-	-	-	-	-
Ck1	40- 57	7.6	7.3	-	-	-	-	-	-	-	15.6	11	2	-	-	-	-	-	-
Ck2	57- 93	7.7	7.3	-	-	-	-	-	-	-	15.6	9	1	-	-	-	-	-	-
Ck3	93-120	7.8	7.6	-	-	-	-	-	-	-	17.7	9	1	-	-	-	-	-	-

PHYSICAL ANALYSIS

Horizon	Particle Size Distribution % >2mm	vc	c	m	f	vf	S	Si	C	Text Class	Moisture Status % 1/3 atm	15 atm	AWC* %	Bulk Density g/cc	Hydr Cond cm/hr
Ah	2	0	2	9	17	8	36	37	27	L	24	18	6	-	-
Bm	3	0	3	9	17	8	37	32	31	CL	22	16	6	-	-
Ck1	4	0	3	9	17	9	38	35	27	L	19	10	9	-	-
Ck2	3	0	2	9	20	8	39	33	28	CL	-	-	-	-	-
Ck3	3	1	2	5	12	9	29	40	31	CL	22	11	11	-	-

*TEC = total exchange capacity; SSP = soluble sodium percentage; SAR = sodium absorption rates; AWC = available water holding capacity

ROCKFORD SERIES

Location: NE31, Twp 3, Rge 19, W4

Classification: Orthic Black Chernozemic

Parent Material: Medium to moderately fine textured ice-contact material

Land Use: Rangeland

Profile Description

Horizon	Depth cm	
Ah	0-10	Very dark brown (10YR 2/2 m); very dark grayish brown (10YR 3/2 d); loam; 10% gravelly, coarse fragments;s strong, medium subangular blocky; hard; plentiful, medium, random roots; clear, wavy boundary; 8-12 cm thick; neutral.
Bm1	10-30	Dark brown (10YR 4/3 m); yellowish brown (10YR 5/4 d); loam; 10% gravelly, coarse fragments; moderate to strong, medium prismatic, and moderate to strong, medium angular blocky; hard; slightly plastic; few, fine, vertical roots; gradual, wavy boundary; 20-25 cm thick; neutral.
Bm2	30-45	Dark brown (10YR 3/3 m); dark yellowish brown (10YR 4/4 d); sandy loam; 10% gravelly, coarse fragments; moderate, medium, prismatic; slightly hard; nonplastic; few, fine, vertical roots; clear, wavy boundary; 15-27 cm thick; neutral.
Ck1	45-105	Yellowish brown (10YR 5/4 m), brown (10YR 5/3 d); gravelly, sandy loam; 40% gravelly and cobbly, coarse fragments; 5% boulders; massive; loose; nonplastic; moderately calcareous; few, fine, vertical roots; gradual, wavy boundary; 40-75 cm thick.
Ck2	105-132	Yellowish brown (10YR 5/4 m); brown (10YR 5/3 d); gravelly loam; 30% gravelly and cobbly, coarse fragments; massive; very friable, slightly plastic; moderately calcareous; gradual, wavy boundary; 27-35 cm thick.
Ck3	132-180	Dark yellowish brown (10YR 4/4 m); light yellowish brown (10YR 6/4 d); gravelly clay loam; 20% gravelly, coarse fragment; 15% boulders; massive; friable; plastic; moderately calcareous.

CHEMICAL ANALYSIS

Horizon	Depth cm	pH		N %	Org. C %	C/N	Exchange Cations me/100g				TEC* me/100g	$CaCO_3$ equiv. %	Elec. Cond. dS/m	Water Soluble Salts me/l				SSP* %	SAR*
		H_2O	$CaCl_2$				Na	K	Ca	Mg				Na	K	Ca	Mg		
Ah	0- 10	7.4	7.1	0.29	4.02	14	0.0	0.6	17.7	3.2	26.2	0.1	-	-	-	-	-	-	-
bm1	10 30	7.2	6.8	-	0.99	-	0.0	0.4	13.3	3.0	19.7	-	-	-	-	-	-	-	-
Bm2	30- 45	7.2	6.9	-	0.84	-	0.0	0.3	13.9	2.6	16.2	0.3	-	-	-	-	-	-	-
Ck1	45-105	7.7	6.9	-	-	-	-	-	-	-	11.5	11.2	<1	-	-	-	-	-	-
Ck2	105-132	7.6	7.2	-	-	-	-	-	-	-	12.1	9.6	<1	-	-	-	-	-	-
Ck3	132-180	7.7	7.3	-	-	-	-	-	-	-	14.5	9.2	<1	-	-	-	-	-	-

PHYSICAL ANALYSIS

Horizon	Particle Size Distribution %									Text. Class	Moisture Status %		AWC* %	Bulk Density g/cc	Hydr. Cond. cm/hr
	-2mm	vc	c	m	f	vf	S	Si	C		1/3 atm	15 atm			
Ah	-	2	8	18	18	5	51	27	22	L	22	17	5	-	-
Bm1	-	2	7	16	17	3	45	33	22	L	17	11	6	-	-
Bm2	-	1	8	27	25	5	66	14	20	SL	13	9	4	-	-
Ck1	-	4	14	20	20	5	63	19	18	GSL	13	8	5	-	-
Ck2	-	2	9	16	17	7	51	29	20	GL	13	7	6	-	-
Ck3	-	1	3	9	16	7	36	35	29	GCL	20	10	10	-	-

*TEC = total exchange capacity; SSP = soluble sodium percentage; SAR = sodium absorption rates; AWC = available water holding capacity.

SEXTON SERIES

Location: WC26, Twp 5, Rge 20, W4

Classification: Cumulic Humic Regosol

Parent Material: Medium to moderately coarse textured fluvial

Land Use: Rangeland

Profile Description

Horizon	Depth cm	
Ah	0-23	Very dark brown (10YR 3.5/2.5 d); fine sandy loam; very weak, fine, subangular blocky and weak, very fine granular; soft; abundant, fine and very fine, random roots; clear, smooth boundary; 21-25 cm thick; neutral.
Ck	23-34	Pale brown (10YR 6/3 d); fine sandy loam; massive; soft; weakly calcareous; plentiful, very fine and fine roots; abrupt irregular boundary; 11-30 cm thick.
Ahkb1	34-53	Dark grayish brown (10YR 4/2 d); fine sandy loam; soft; massive; weakly calcareous plentiful, very fine and fine, random roots; abrupt smooth boundary; 8-20 cm thick.
Ckb1	53-68	Pale brown (10YR 6/3 d); fine sandy loam; massive; soft; weakly calcareous; few, fine, vertical roots; abrupt, smooth boundary; 13-77 cm thick.
Ahkb2	68-74	Brown (10YR 5/3.5 d); sandy loam; massive; soft; weakly calcareous; few, fine, vertical roots; abrupt, smooth boundary; 5-6 cm thick.
Ckb2	74-100	Pale brown (10YR 6/3 d); loam; massive; soft; weakly calcareous; few fine vertical roots.

CHEMICAL ANALYSIS

Horizon	Depth cm	pH		N %	Org. C %	C/N	Exchange Cations me/100g				TEC* me/100g	$CaCO_3$ equiv. %	Elec. Cond. dS/m	Water Soluble Salts me/l				SSP* %	SAR*
		H_2O	$CaCl_2$				Na	K	Ca	Mg				Na	K	Ca	Mg		
Ah	0- 23	7.7	7.2	0.17	1.58	9	-	-	-	-	12.1	1	<1	-	-	-	-	-	-
Ck	23- 34	7.9	7.3	-	0.60	-	-	-	-	-	10.6	5	<1	-	-	-	-	-	-
Ahkb1	34- 53	7.9	7.4	-	0.91	-	-	-	-	-	8.6	2	<1	-	-	-	-	-	-
Ckb1	53- 68	8.2	7.5	-	0.52	-	-	-	-	-	6.6	4	<1	-	-	-	-	-	-
Ckb2	74-100	8.7	8.0	-	0.24	-	-	-	-	-	7.6	7	3	-	-	-	-	-	-

PHYSICAL ANALYSIS

Horizon	Particle Size Distribution %									Text. Class	Moisture Status %		AWC* %	Bulk Density g/cc	Hydr. Cond. cm/hr
	>2mm	vc	c	m	f	vf	S	Si	C		1/3 atm	15 atm			
Ah	-	0	1	10	39	15	65	24	11	FSL	12	9	3	-	-
Ck	-	0	0	9	28	17	54	33	13	FSL	11	7	4	-	-
Ahkb1	-	0	1	15	40	13	69	20	11	FSL	10	5	5	-	-
Ckb1	-	0	1	7	37	19	62	29	9	FSL	10	5	5	-	-
Ckb2	-	0	1	5	27	17	50	39	11	L	15	7	8	-	-

*TEC < total exchange capacity; SSP = soluble sodium percentage; SAR = sodium absorption rates; AWC = available water holding capacity.

SLOUGHAY SERIES

Location: SW32, Twp 5, Rge 16, W4

Classification: Rego Humic Gleysol

Parent Material: Moderately fine textured lacustrine

Land Use: Cropland

Profile Description

Horizon	Depth cm	
Ap	0-16	Dark brown (10YR 3/3); silty clay loam; weak to moderate, fine to medium, subangular blocky; friable; slightly plastic; smooth, clear boundary, 14-18 cm thick; slightly acid.
Cg	16-40	Dark gray (5Y 4/1 m); silty clay loam; massive; friable; very plastic; gradual, wavy boundary; 22-25 cm thick; neutral.
Ckg1	40-62	Dark gray (5Y 4/1 m); silty clay; massive, friable; very plastic; weakly calcareous; gradual, wavy boundary; 20-25 cm thick.
Ckg2	62-78	Dark gray (10YR 4.5/1 m); silty clay; massive; friable, plastic; moderately calcareous; clear, wavy boundary; 15-17 cm thick.
Ckg3	78-120	Brown (10YR 5/3 m); faint, fine grayish brown (2.5Y 5/2) mottles; loam; massive; friable; plastic; moderately calcareous.

CHEMICAL ANALYSIS

		pH					Exchange Cations me/100g				TEC*	CaCO$_3$	Elec.	Water Soluble Salts me/l					
Horizon	Depth cm	H$_2$O	CaCl$_2$	N %	Org. C %	C/N	Na	K	Ca	Mg	me/ 100g	equiv. %	Cond. dS/m	Na	K	Ca	Mg	SSP* %	SAR*
Ap	0- 16	6.8	6.4	0.16	1.49	9	0.1	2.0	9.7	3.7	17.8	-	<1	-	-	-	-	-	-
Cg	16- 40	7.0	6.6	-	0.55	-	0.4	2.3	10.3	6.8	20.2	-	<1	-	-	-	-	-	-
Ckg1	40- 62	8.0	7.1	-	0.47	-	-	-	-	-	-	0.5	<1	-	-	-	-	-	-
Ckg2	62- 78	8.3	7.5	-	-	-	-	-	-	-	-	9	<1	-	-	-	-	-	-
Ckg3	78-120	8.4	8.1	-	-	-	-	-	-	-	-	15.0	<1	-	-	-	-	-	-

PHYSICAL ANALYSIS

	Particle Size Distribution %										Moisture Status %			Bulk	Hydr.
Horizon	>2mm	vc	c	m	f	vf	S	Si	C	Text. Class	1/3 atm	15 atm	AWC* %	Density g/cc	Cond. cm/hr
Ap	-	-	-	-	-	-	20	51	29	SiCL	29	18	11	-	-
Cg	-	-	-	-	-	-	13	47	40	SiCL	32	22	10	-	-
Ckg1	-	-	-	-	-	-	13	33	43	SiC	-	-	-	-	-
Ckg2	-	-	-	-	-	-	17	42	41	SiC	33	24	9	-	-
Ckg3	-	-	-	-	-	-	39	37	24	L	-	-	-	-	-

*TEC = total exchange capacity; SSP = soluble sodium percentage; SAR = sodium absorption rates; AWC = available water holding capacity.

WILDA SERIES

Location: C7, Twp 4, Rge 18, W4

Classification: Rego Dark Brown Chernozemic

Parent Material: Moderately fine to medium textured, moderately calcareous till

Land Use: Cropland

Profile Description

Horizon	Depth cm	
Apk	0-15	Dark brown (10YR 3/3 m); dark grayish brown (10YR 4/2 d); clay loam; weak to moderate, fine to medium, subangular blocky and weak, fine, granular; friable, hard; very weakly effervescent; clear, wavy boundary; 10-19 cm thick.
Ck1	14-41	Brown (10YR 5/3 m); clay loam; massive; very friable; moderately calcareous; gradual, wavy boundary; 20-28 cm thick.
Ck2	41-75 +	Light brownish gray (2.5Y 6/2 m); clay loam; massive; very friable; moderately calcareous. 2% coarse fragments throughout profile.

CHEMICAL ANALYSIS

Horizon	Depth cm	pH		N %	Org. C %	C/N	Exchange Cations me/100g				TEC* me/100g	$CaCO_3$ equiv %	Elec. Cond. dS/m	Water Soluble Salts me/l				SSP* %	SAR*
		H_2O	$CaCl_2$				Na	K	Ca	Mg				Na	K	Ca	Mg		
Apk	0-15	7.5	7.1	0.19	1.86	10	-	-	-	-	23.2	0.3	<1	-	-	-	-	-	-
Ck1	15-41	7.8	7.2	-	1.02	-	-	-	-	-	20.6	13	<1	-	-	-	-	-	-
Ck2	41-75	7.9	7.6	-	0.31	-	-	-	-	-	9.0	11	<1	-	-	-	-	-	-

PHYSICAL ANALYSIS

Horizon	Particle Size Distribution %									Text. Class	Moisture Status %		AWC* %	Bulk Density g/cc	Hydr. Cond cm/hr
	>2mm	vc	c	m	f	vf	S	Si	C		1/3 atm	15 atm			
Apk	-	0	1	6	16	8	31	38	31	CL	24	16	8	-	-
Ck1	-	0	1	5	9	6	21	42	37	CL	24	13	11	-	-
Ck2	-	0	1	5	14	8	28	38	34	CL	25	15	10	1.57	0.9

*TEC = total exchange capacity; SSP = soluble sodium percentage; SAR = sodium absorption rates; AWC = available water holding capacity.

APPENDIX C: Available moisture and aridity classes for individual map units in Warner County.

Map unit	AWC	Aridity
ANBV1/3	2	9
ANBV1/4	2	9
BUT1/3-2	2	9
BUT3/3-2	2	9
BV:G4/4	1	10
BV:L1/3	1	10
BZR1/4	3	6
BZR1/5	3	6
BZR1/5D-6D	3	6
BZR2/4	3	6
BZR2/5	3	6
BZR4/6D	3	6
BZRF1/5	3	6
BZRF1/5D	3	6
BZRF1/6	3	6
BZRF2/5	3	6
BZSD1/4	3	6
CFD1/2-3	3	8
CFD2/3-2	3	8
CFD3/2-3	3	8
CFBV2/3	3	8
CFCH7/3-2	3	8
CFMS3/3	3	8
CFMS3/3:R	3	8
CHN2/2	3	8
CHN5/2	4	8
CHBV1/3-2:R	2	9
CLD1/2-3	4	6
CLD3/2-3	4	6
CLD3/2-3:R	4	6
CLLE1/2	4	6
CLLE1/2:R	4	6
CLR1/5	3	8
CRD1/2	3	7
CRD1/2:R	3	7
CRD1/3	3	7
CRD1/3:R	3	7
CRD1/4	3	7
CRD1/4:R	3	7
CRD1/4D	3	7
CRD2/3-4	3	7
CRD2/3-4:R	3	7
CRD3/3	3	7
CRD3/3:R	3	7
CRD4/4	3	7
CRD4/4:R	3	7
CRD4/4D	3	7
CRD4/4D:R	3	7
CRD4/5	3	7
CRD4/5:R	3	7
CRD4/5D	3	7
CRD6/3	2	8
CRD6/5	2	8
CRD7/4D	3	7
CRD7/4D:R	3	7
CR:P1/3-4:R	3	7
CRNE1/3:R	2	8
CRNE3/3:R	2	8
CRWN1/3-2	3	7
CRWN1/3-2:R	3	7
CRWN1/4	3	7
CRWN2/3	3	7
CRWN5/3	3	7
CRWN7/3	3	7
CVD1/3	1	10
DHP1/2	4	6
DHP1/2:R	4	6
DL		
FOKS1/3	2	9
G		
GEM3/2-3	3	8
GLS1/2	3	7
GR:E1/3	4	6
GR:E1/3:R	4	6
HDHU1/3-4	4	7
HDHU1/3-4:R	4	7
HU:E1/3-4	4	7
HU:E1/3-4R	4	7
HEG1/3	4	5
HEG7/2	4	5
HRK1/3-4	1	9
HRK1/3-4:R	1	9
HRK4/4	1	9
HRK4/4:R	1	9
HRX4/5	1	9
HRNE1/3	1	9
HRNE1/4	1	9
JAT3/2	4	4
KBD1/2-3	3	8
KHO3/2-3	3	7
KHO3/2-3:R	3	7
KGT1/2	5	4
KNT1/4	0	9
KSR1/3	2	8
KSR1/4	2	8
KSR2/3	2	8
KSR2/3:R	2	8
KS:G1/3:R	1	9
KS-G1/4:R	1	9
KSMG1/3	2	8
KSMG1/4	2	8
KSOA1/3	2	8
LET1/2-3	3	7
LET1/2-3:R	3	7
LET3/2-3	3	7
LET3/2-3:R	3	7
LEKS2/4	2	8
LEXS6/3-4	2	8
LEOA1/2-3	3	7
LEOA1/4D	3	7
LLD1/2-3	3	7
LLD1/2-3:R	3	7
LUP1/2-3	4	6
LVY1/2	3	6
MAB1/3-4	3	8
MAB2/3	3	8
MAB2/4	3	8
MAB4/4	3	8
MAB7/4	3	8
MA:P1/4	3	8
MACF1/3	3	8
MACF2/3	3	8
MACF7/3	3	8
MCN3/3-3	3	8
MCN7/3-2	3	8
MC:S1/2	3	8
MGCR1/3-4	3	7
MGHR1/4-5:R	2	8
MKR1/3	1	10
MSN1/3	3	8
MSN1/3:R	3	8
MSN1/4	3	8
MSN1/4:R	3	8
MSN2/4	3	8
MSN3/3-2	3	8
MSN3/3-3:R	3	8
MSN3/4-3	3	8
MSN4/4	3	8
MSN4/4:R	3	8
MSN4/5	3	8
MSN5/3	2	9
MSN6/4	2	9
MSN6/5	2	9
MSN7/4	3	8
MSN7/4:R	3	8
MS:P1/4-5	3	8
MSAN1/3	2	9
MSAN1/3:R	2	9
MSAN1/4	2	9
MSAN1/4:R	2	9
MSCF1/3	3	8
MSCF1/3:R	3	8
MSCF2/3	3	8
MSCF2/3:R	3	8
MSCF7/3	3	8
MSF7/3:R	3	8
NED1/4-3	0	10
NED1/4-3:R	0	10
PUN1/4-3	0	10
PUN1/4-3:R	0	10
PUR1/4	3	7
PUR1/4D	3	7
PUR1/5	3	7
PUR1/6D	3	7
PUR2/5-4	3	7
PUR4/4	3	7
PUR4/4:R	3	7
PUR4/5	3	7
PUR4/5D	3	7
PUR4/6D	3	7
PUR5/4	2	8
PUR7/4-3	3	7
PUR7/4-3:R	3	7
PUBZ1/4D	3	7
PUBZ1/5	3	7
PUBZ1/5	3	7
PUBZ1/6D	3	7
PUBZ1/6D	3	7
PUBZ2/4	3	7
PUBZ2/5	3	7
PULU1/3-4	3	7
PULU1/3-4:R	3	7
PULU7/3D	4	6
PULU7/3D:R	4	6
PURF2/6	3	7
RAM1/3:R	2	9
RB1		
RS2		
RS3		
RS4		
RDM2/4	3	7
RDM4/4	3	7
RDWN1/3	3	7
RFBZ1-4	2	7
RFKN1/5	1	8
RFKN2/4	1	8
S		
SLY1/2	4	7
SOF1/3	3	6
SOL1/4	3	7
SOL1/5D	3	7
SOL1/60	3	7
SPS3/2	4	7
SXT1/2-3	2	8
SXT3/2-3	2	8
TEP1/2	5	6
VAC4/4-3:R	2	9
VAC7/3:R	2	9
VEB1/5	2	8
VEB1/5:R	2	8
VTR3/2-3	4	6
VTR3/2-3:R	4	6
WDW1/2	3	8
WID1/5	3	7
WID1/6D	3	7
WLH1/2	4	6
WNY1/2-3	3	7
WNY1/2-3:R	3	7
WNY3/2-3	3	7
WNY3/2-3:R	3	7
WNCR3/3-2	3	7
WNCR3/3-2:R	3	7
WNLE1/2-3	3	7
WTN1/3	4	7
WTN3/2	4	7

APPENDIX D

TABLE 24: Predicted Soil Erodability of Map Units in Warner County

		ANNUAL EROSION (A)		
MAP UNIT	BARE SOIL	GRASS	S. WHEAT SUMMER-FALLOW classes[1]	W. WHEAT SUMMER-FALLOW
ANBV1/3	2	1	1	1
ANBV1/4	3	1	1	1
BUT1/3-2	1	1	1	1
BUT3/3-2	1	1	1	1
BV:G4/4	3	1	1	1
BV:L1/3	2	1	1	1
BZR1/4	2	1	1	-
BZR1/5	4	1	3	-
BZR1/5D-6D	5	1	3	-
BZR2/4	2	1	1	-
BZR2/5	4	1	3	-
BZR4/6D	6	1	4	-
BZRF1/5	4	1	2	-
BZRF1/5D	4	1	3	-
BZRF1/6	5	1	3	-
BZRF2/5	4	1	2	-
BZSD2/4	2	1	1	-
CFD1/2-3	1	1	1	1
CFD2/3-2	1	1	1	1
CFD3/2-3	1	1	1	1
CFBV2/3	2	1	1	1
CFCH7/3-2	1	1	1	1
CFMS3/3	2	1	1	1
CFMS3/3:R	2	1	1	1
CHN2/2	1	1	1	1
CHN5/2	1	1	1	1
CHBV1/3-2:R	1	1	1	1
CLD1/2-3	1	1	1	1
CLD3/2-3	1	1	1	1
CLD3/2-3:R	1	1	1	1
CLLE1/2	1	1	1	1
CLLE1/2:R	1	1	1	1
CLR1/5	5	1	4	3
CRD1/2	1	1	1	1
CRD1/2:R	1	1	1	1
CRD1/3	1	1	1	1
CRD1/3:R	2	1	1	1
CRD1/4	3	1	2	1
CRD1/4:R	4	1	3	2
CRD1/4D	4	1	2	2
CRD2/3-4	2	1	1	1
CRD2/3-4:R	2	1	1	1
CRD3/3	1	1	1	1
CRD3/3:R	2	1	1	1
CRD4/4	3	1	2	1
CRD4/4:R	5	1	3	2
CRD4/4D	4	1	2	2
CRD4/4:R	5	1	3	3
CRD4/5	5	1	3	3
CRD4/5:R	6	1	4	3
CRD4/5D	6	1	3	3
CRD6/3	1	1	1	1
CRD6/5	5	1	3	3
CRD7/4D	4	1	2	2
CRD7/4D:R	5	1	3	3
CR:P1/3-4:R	3	1	1	1
CRNE1/3:R	2	1	1	1
CRNE3/3:R	2	1	1	1
CRWN1/3-2	1	1	1	1
CRWN1/3-2:R	2	1	1	1
CRWN1/4	3	1	1	1
CRWN2/3	2	1	1	1
CRWN6/3	2	1	1	1
CRWN7/3	2	1	1	1
CVD1/3	1	1	1	1
DHP1/2	1	1	1	1
DHP1/2:R	1	1	1	1
DL	5	-	-	-
FOKS1/3	1	1	1	1
G	1	-	-	-
GEM3/2-3	1	1	1	1
GLS1/2	1	1	1	1
GR:E1/3	2	1	1	1
GR:E1/3:R	3	1	1	1
HDHU1/3-4	3	1	2	1
HDHU1/3-4:R	3	1	2	2
HU:E1/3-4	3	1	1	1
HU:E1/3-4R	3	1	2	1
HEG1/3	1	1	1	1
HEG7/2	1	1	1	1
HRK1/3-4	1	1	1	1
HRD1/3-4:R	1	1	1	1
HRK4/4	1	1	1	1
HRK4/4:R	1	1	1	1
HRK4/5	2	1	1	1
HRNE1/3	1	1	1	1
HRNE1/4	1	1	1	1
JAT3/2	1	1	-	-
KDB1/2-3	1	1	1	1
KHD3/2-3	1	1	1	1
KHD3/2-3:R	2	1	1	1
KGT1/2	1	1	1	1

APPENDIX D con't

		ANNUAL EROSION (A)		
MAP UNIT	BARE SOIL	GRASS	S. WHEAT SUMMER-FALLOW	W. WHEAT SUMMER-FALLOW
			classes[1]	
KNT1/4	1	1	1	1
KSR1/3	1	1	1	1
KSR1/4	1	1	1	1
KSR2/3	1	1	1	1
KSR2/3:R	1	1	1	1
KS:G1/3:R	1	1	1	1
KS:G1/3:R	3	1	1	1
KSMG1/3	1	1	1	1
KSMG1/4	1	1	1	1
KSOA1/3	1	1	1	1
LET1/2-3	1	1	1	1
LET1/2-3:R	1	1	1	1
LET3/2-3	1	1	1	1
LET3/2-3:R	1	1	1	1
LEKS2/4	3	1	1	1
LEKS6/3-4	2	1	1	1
LEOA1/2-3	1	1	1	1
LEOA1/4D	5	1	2	2
LLD1/2-3	1	-	-	-
LLD1/2-3:R	2	-	-	-
LUP1/2-3	1	1	1	1
LVY1/2	1	1	1	1
MAB1/3-4	2	1	1	1
MAB2/3	1	1	1	1
MAB2/4	3	1	1	1
MAB4/4	3	1	1	1
MAB7/4	3	1	1	1
MA:P1/4	2	1	1	1
MACF1/3	2	1	1	1
MACF2/3	2	1	1	1
MACF7/3	2	1	1	1
MCN3/3-2	1	1	1	1
MCN7/3-2	1	1	1	1
MC:S1/2	1	1	1	1
MGCR1/3-4	2	1	1	1
MGHR1/4-5:R	4	1	2	2
MKR1/3	1	1	1	1
MSN1/3	2	1	1	1
MSN1/3:R	2	1	1	1
MSN1/4	3	1	1	1
MSN1/4:R	5	1	3	3
MSN2/4	3	1	1	1
MSN3/3-2	1	1	1	1
MSN3/3-2:R	2	1	1	1
MSN3/4-3	3	1	1	1
MSN4/4	3	1	2	1
MSN4/4:R	5	1	3	3
MSN4/5	5	1	3	3
MSN6/3	1	1	1	1
MSN6/4	3	1	1	1
MSN6/5	5	1	3	3
MSN7/4	3	1	2	2
MSN7/4:R	5	1	3	3
MS:P1/4-5	4	1	2	2
MSAN1/3	1	1	1	1
MSAN1/3:R	2	1	1	1
MSAN1/4	3	1	1	1
MSAN1/4:R	4	1	3	2
MSCF1/3	2	1	1	1
MSCF1/3:R	2	1	1	1
MSCF2/3	2	1	1	1
MSCF2/3:R	2	1	1	1
MSCF7/3	2	1	1	1
MSCF7/3:R	2	1	1	1
NED1/4-3	2	1	1	1
NED1/4-3:R	2	1	1	1
PUN1/4-3	2	1	1	1
PUN1/4-3:R	2	1	1	1
PUR1/4	2	1	1	1
PUR1/4D	3	1	2	1
PUR1/5	4	1	3	2
PUR1/6D	6	1	4	-
PUR2/5-4	3	1	2	1
PUR4/4	3	1	1	1
PUR4/4:R	5	1	3	2
PUR4/5	5	1	3	3
PUR4/5D	5	1	3	3
PUR4/6D	6	1	5	-
PUR6/4	3	1	1	1
PUR7/4-3	2	1	1	1
PUR7/4-3:R	2	1	1	1
PUBZ1/4	2	1	1	1
PUBZ1/4D	3	1	2	1
PUBZ1/5	4	1	3	2
PUBZ1/5D	5	1	3	3
PUBZ1/6D	6	1	4	-
PUBZ2/4	2	1	1	1
PUBZ2/5	4	1	3	2
PULU1/3-4	2	1	1	1
PULU1/3-4:R	2	1	1	1
PULU7/3D	1	1	1	1
PULU7/3D:R	2	1	1	1

APPENDIX D con't

		ANNUAL EROSION (A)		
MAP UNIT	BARE SOIL	GRASS	S. WHEAT SUMMER-FALLOW	W. WHEAT SUMMER-FALLOW
			classes[1]	
PURF2/6	5	1	3	-
RAM1/3:R	2	1	1	1
RB1	6	1	4	-
RB2	6	1	-	-
RB3	6	1	-	-
RB4	5	1	3	-
RDM2/4	3	1	1	1
RDM4/4	3	1	1	1
RDWN1/3	2	1	1	1
RFBZ1/4	3	1	1	1
RFKN1/5	3	1	2	1
RFKN2/4	1	1	1	1
S	2	-	-	-
SLY1/2	1	1	1	1*
SOF1/3-4	2	1	1	-
SOL1/4	3	1	1	1
SOL1/5D	5	1	3	3
SOL1/6D	6	1	4	4
SPS3/2	1	1	1	1
SXT1/2-3	1	1	1	1
SXT3/2-3	1	1	1	1
TEP1/2	1	1	1	1*
VAC4/4-3:R	3	1	1	1
VAC7/3:R	2	1	1	1
VEB1/5	5	1	3	3
VEB1/5:R	6	1	4	3
VTR3/2-3	1	1	1	1
VTR3/2-3:R	2	1	1	1
WDW1/2	1	1	1	1
WID1/5	5	1	3	3
WID1/6D	6	1	5	-
WLH1/2	1	1	1	1*
WNY1/2-3	1	1	1	1
WNY1/2-3:R	1	1	1	1
WNY3/2-3	1	1	1	1
WNY3/2-3:R	1	1	1	1
WNCR3/3-2	1	1	1	1
WNCR3/3-2:R	1	1	1	1
WNLE1/2-3	1	1	1	1
WTN1/3	1	1	1	1
WTN3"/	1	1	1	1

NOTE:

1. **Class 1 = 0-6 t/ha/yr; Class 2 = 6-11 t/ha/yr; Class 3 = 11-22 t/ha/yr Class 4 = 22-33 t/ha/yr; Class 5 = 33-55 t/ha/yr; Class 6 = 55 t/ha/yr**

* DRAINED SOILS ASSUMED

Appendix E: Glossary of Terms.

acid soil - A soil having a pH of less than 7.0.

aggregate - A group of soil particles cohering so as to behave mechanically as a unit.

alkaline soil - Any soil that has a pH greater than 7.0.

alluvial deposit - (alluvium) - Material deposited by moving water.

apran - an extensive, continuous, outspread, blanket-like deposit of alluvial, glacial, eolian or other unconsolidated material derived from an identifiable source, and deposited at the base of a mountain or highland.

atterberg limits - Various moisture contents of a soil at which it changes from one major physical state to another. The liquid limit is the moisture at which a soil passes from a plastic to liquid state. The plastic limit is the moisture content at which a soil changes from a semi-solid to a plastic state.

badland - A land type generally devoid of vegetation and broken by an intricate maze of narrow ravines, sharp crests, and pinnacles resulting from a serious erosion of soft geologic materials. Most common in arid of semiarid regions.

bedrock - The solid rock underlying soils and the regolith or exposed at the surface.

blanket - A relatively uniform cover of unconsolidated material which is thick enough to mask irregularities in the underlying unit, or exceeds 1 m in thickness.

bulk density, soil - The mass of dry soil per unit bulk volume.

calcareous soil - Soil containing sufficient calcium carbonate (often with magnesium carbonate) to effervesce visibly when treated with cold 0.1N hydrochloric acid.

capability class - (soil) - The class indicates the general suitability of the soils for agricultural use. It is a grouping of subclasses that have the same relative degree of limitation of hazard. The limitation or hazard becomes progressively greater from Class 1 to Class 7.

capability subclass - (soils) - This is a grouping of soils with similar kinds of limitations and hazards. It provides information on the kind of conservation problem or limitation. The class and subclass together provide the map user with information about the degree and kind of limitation for broad land use planning and for the assessment of conservation needs.

carbon-nitrogen ratio - The ratio of the weight of organic carbon to the weight of total nitrogen in a soil or in organic material. It is obtained by dividing the percentage of organic carbon (C) by the percentage of total nitrogen (N).

cation - An ion carrying a positive charge of electricity; the common soil cations are calcium, magnesium, sodium, potassium, and hydrogen.

cation exchange capacity (C.E.C.) - A measure of the total amount of exchangeable cations that can be held by the soil; it is expressed in terms of milliequivalents per 100 g of soil.

chroma - The chroma notation indicates the degree of departure of a given hue from a neutral gray of the same value. The scales of chroma extend from 0 for a neutral gray out to 8. A strong brown, for example, has a chroma of 6.

classification, soil - The systematic arrangement of soils into categories and classes on the basis of their characteristics. Broad groupings are made on the basis of general characteristics and subdivisions on the basis of more detailed differences in specific properties.

clas - as a particle-size term: a size fraction <0.002 mm equivalent diameter.

clod - A compact, coherent mass of soil produced by digging or plowing.

coarse fragments - Rock or mineral particles >2.0 mm in diameter.

coarse texture - The texture exhibited by sands, loamy sands, and sandy loams except very fine sandy loam. A soil containing large quantities of these textural classes.

concretion - A local concentration of a chemical compound, such as calcium carbonate or iron oxide, in the form of a grain or nodule of varying size, shape, hardness and color.

consistency - (i) The resistance of a material to deformation or rupture. (ii) The degree of cohesion or adhesion of the soil mass.

control section - The vertical section upon which soil classification is based.

creep - A slow mass movement of soil material down steep slopes primarily under the influence of gravity, but aided by saturation with water and alternate freezing and thawing.

deposit - Material left in a new position by a natural transportation agent such as water, wind, ice, or gravity, or by the activity of man.

dissected - A relatively even topographic surface which has been sculptured or destroyed by the formation of gullies, ravines or canyons or other kinds of valleys by erosion.

droughty soil - Sandy or very rapidly drained soil.

dryland farming - The practice of crop production in low-rainfall areas without irrigation.

dunes - Wind built ridges and hills of sand formed in the same manner as snowdrifts. They are started by some obstruction such as a bush, boulder, fence, or other obstacle which causes an eddy, or otherwise thwarts the sand-laden wind. Once begun, the dunes themselves offer further resistance and they grow to form various shapes.

eluviation - The removal of soil material in suspension or in solution from a layer or layers of soil.

end moraine - A ridge like accumulation of drift built along any part of the margin of an active glacier.

engineering tests - Laboratory tests made to determine the physical properties of soils that affect their uses for various types of engineering construction.

eolian deposit - Material deposited by wind, including both loess and dune sand.

erosion - The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep.

esker - A winding ridge of irregularly stratified sand, gravel and cobbles laid down under the ice by a rapidly flowing glacial stream.

fan - Material deposited by a stream when it emerges from hills unto a lowland where there is a marked decrease in gradiant.

fertility, soil - The status of a soil with respect to the amount and availability to plants of elements necessary for plant growth.

fertilizer - Any organic or inorganic material of natural or synthetic origin which is added to a soil to supply certain elements essential to the growth of plants.

fine texture - Consisting of or containing large quantities of the fine fractions, particularly of silt and clay.

floodplain - The land bordering a stream, built up of sediments from overflow of the stream and subject to inundation when the stream is at flood stage.

fluvial deposit - All sediments, past and present, deposited by flowing water, including glaciofluvial deposits.

friable - A consistency term pertaining to the ease of crumbling of soils.

frost-free period - Season of the year between the last frost of spring and first frost of fall.

glacial drift - Embraces all rock material transported by glacier ice, glacial meltwater, and rafted by icebergs. This term includes till, stratified drift and scattered rock fragments.

glaciofluvial deposits - Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and may occur in the form of outwash plains, deltas, kames, eskers, and kame terraces.

gravelly - containing appreciable or significant amounts of gravel.

ground moraine - Generally an unsorted mixture of rocks, boulders, sand, silt and clay deposited by glacial ice. The predominant material is till, though stratified drift is present in places. The till is thought to have accumulated largely by lodgment beneath the ice but partly also by being let down from the upper surface of the ice through the ablation process. Ground moraine is most commonly in the form of undulating plains with gently sloping swells, sags and enclosed depressions.

groundwater - That portion of the total precipitation which at any particular time is either passing through or standing in the soil and the underlying strata and is free to move under the influence of gravity.

horizon - A layer in the soil profile approximately parallel to the land surface with more or less well-defined characteristics that have been produced through the operation of soil forming processes. Soil horizons may be organic or mineral.

hue - One of the three variables of color. It is caused by light of certain wavelengths and changes with the wavelength.

hummocky - abounding in rounded or conical knolls or mounds, generally of equidimensional shape and not ridgelike.

ice contact material - Stratified drift deposited in contact with melting glacier ice, such as an esker, kame, kame terrace, or a feature marked by numerous kettles.

illuviation - The process of deposition of soil material removed from one horizon to another in the soil; usually from an upper to a lower horizon in the soil profile. Illuviated substances include silicate clay, iron and aluminum hydrous oxides and/or organic matter.

immature soil - A soil with indistinct or only slightly developed horizons.

impeded drainage - A condition which hinders the movement of water through soils under the influence of gravity.

impervious - Resistant to penetration by fluids or by roots.

indicator plants - Plants characteristics of specific soil or site conditions.

infiltration - The downward entry of water into the soil.

intergrade - A soil that possesses moderately well-developed distinguishing characteristics of two or more genetically related taxa.

irrigation - The artificial application of water to the soil for the benefit of growing crops.

kame - An irregular shaped ridge or hill of stratified glacial drift.

lacustrine deposit - Material deposited in lake water and later exposed either by lowering the water level of by uplift of the land. These sediments range in texture from sands to clays.

landscape - All the natural features such as fields, hills, forests, water, etc., which distinguish one part of the earth's surface from another part. Usually that portion of land or territory which the eye can comprehend in a single view, including all its natural characteristics.

leaching - The removal of materials in solution from the soil.

lime concretion - An aggregate of precipitated calcium carbonate, or of other material cemented by precipitated calcium carbonate.

liquid limit - (upper plastic limit) - (i) The water content corresponding to an arbitrary limit between the liquid and plastic states of consistency of a soil. (ii) The water content at which a part of soil, cut by a groove of standard dimensions, will flow together for a distance of 12 mm under the impact of 25 blows in a standard liquid limit apparatus.

lithic - A feature of a soil subgroup which indicates a bedrock contact within 50 cm of the soil surface.

loose - A soil consistency term.

matrix (soil) - The soil material that encloses other soil features. e.g. concretions embedded in a fine-grained matrix.

mature soil - A soil with well-developed soil horizons produced by the natural processes of soil formation.

medium texture - Intermediate between fine-textured and coarse-textured (soils). (It includes the following textural classes: very fine sandy loam, loam, silt loam, and silt).

microrelief - Small-scale, local differences in topography, including mounds, swales, or pits that are only a few feet in diameter and with elevation differences of up to 6 feet.

moderately-coarse texture - Consisting predominantly of coarse particles. (In soil textural classification, it includes all the sandy loams except the very fine sandy loam).

moderately-fine texture - Consisting predominantly of intermediate-size (In soil textural classification, it includes clay loam, sandy clay loam, and silty clay loam).

morphology, soil - The makeup of the soil, including texture, structure consistence, color, and other mineralogical, physical and biological properties of the various horizons of the soil profile.

mottles - Spots or blotches of different color or shades of color interspersed with the dominant color.

Munsel color system - A color designation system that specifies the relative degree of the three simple variables of color: hue, value, and chroma. For example: 10YR 6/4 is a color (or soil) with a hue 10-YR, value - 6, and chroma - 4. These notations can be translated into color names as desired. See chroma, hue, and value.

neutral soil - A soil in which the surface layer, at least to normal plow depth, is neither acid nor alkaline in reaction (pH 6.5-7.5).

organic matter - The decomposition residues of plant material derived from: (a) plant materials deposited on the surface of the soil; and (b) roots that decay beneath the surface of the soil.

outwash - Sediments "washed out" by flowing water beyond the glacier and laid down in thin foreset beds as stratified drift. Particle size may range from boulders to silt.

parent material - The unconsolidated and more or less chemically weathered mineral or organic matter from which the solum of a soil is developed by pedogenic processes.

particle size - The effective diameter of a particle measured by sedimentation, sieving, or micrometric methods.

ped - A unit of soil structure such as a prism, block, or granule, formed by natural processes (in contrast with a clod, which is formed artificially).

pedology - Those aspects of soil science involving the constitution, distribution, genesis and classification of soils.

percolation, soil water- The downward movement of water through soil. Especially, the downward flow of water in saturated or nearly saturated soil at hydraulic gradients of the order of 1.0 or less.

pH, soil - The negative logarithm of the hydrogen-ion activity of a soil. The degree of acidity (or alkalinity) of a soil as determined by means of a glass, quinhydrone, or other suitable electrode or indicator at a specified moisture content or soil-water ratio, and expressed in terms of the pH scale.

phase, soil - A subdivision of a soil type or other unit of classification having characteristics that affect the use and management of the soil, but which do not vary sufficiently to differentiate it as a separate type. A variation in a property or characteristic such as degree of slope, degree of erosion, content of stones, etc.

plastic limit - (i) The water content corresponding to an arbitrary limit between the plastic and the semisolid states of consistency of a soil. (ii) Water content at which a soil will just begin to crumble when rolled into a thread approximately 3 mm in diameter.

plasticity index - The numerical difference between the liquid and the plastic limit or, synonymously, between the lower plastic limit and the upper plastic limit.

platy - Consisting of soil aggregates that are developed predominately along the horizontal axes, laminated; flaky.

profile, soil - A vertical section of the soil through all its horizons and extending into the parent material.

reaction, soils - The degree of acidity or alkalinity of soil, usually expressed as a pH value.

residual material - Unconsolidated and partly weathered mineral materials accumulated by disintegration of consolidated rock in place.

saline soil - A nonalkali soil containing soluble salts in such quantities that they interfere with the growth of most crop plants. The conductivity of the saturation extract is greater than 4 ms/cm, the exchangeable-sodium percentage is less than 15, and the pH is usually less than 8.5.

salinization - The process of accumulation of salts in soils.

sand - A soil particle between 0.05 and 2.0 mm in diameter.

series, soil - The second category (11) in the Canadian Classification system. This is the basic unit of soil classification consisting of soils which are essentially alike in all major profile characteristics except the texture of the surface.

silt - A soil separate consisting of particles between 0.05 to 0.002 mm in equivalent diameter.

soil - The unconsolidated mineral material on the immediate surface of the earth that serves as a natural medium for the growth of land plants.

soil complex - A mapping unit used in detailed and reconnaissance soil surveys where two or more defined soil units are so intimately intermixed geographically that it is impractical, because of the scale used, to separate them.

soil genesis - The mode of origin of the soil with special reference to the processes or soil-forming factors responsible for the development of the solum, or true soil, from the unconsolidated parent material.

soil map - A map showing the distribution of soil types or other soil mapping units in relation to the prominent physical and cultural features of the earth's surface.

soil moisture - Water contained in the soil.

soil structure - The combination or arrangement of primary soil particles into secondary particles, unit, or peds. These secondary units may be arranged in the profile in such a manner as to give a distinctive or characteristic pattern. The secondary units are characterized and classified on the basis of size, shape, and degree of distinctness into classes, types, and grades, respectively.

soil survey - The systematic examination, description, classification, and mapping of soils in an area. Soil surveys are classified according to the kind and intensity of field examination.

soil variant - A soil whose properties are believed to be sufficiently different from other known soils to justify a new series name but comprising such a limited geographic area that creation of a new series is not justified.

solum (plural sola) - The upper horizons of a soil in which the parent material has been modified and within which most plant roots are confined. It consists usually of A and B horizons.

terrace - A level, usually narrow, plain bordering a river, lake, or the sea. Rivers sometimes are bordered by a number of terraces at different levels. There are also man-made terraces.

till - Unstratified glacial drift deposited directly by the ice and consisting of clay, sand, gravel, and boulders intermingled in any proportion.

toposequence - A sequence of related soils that differ, one from the other, primarily because of topography as a soil-formation factor.

value - The value notation indicates the degree of lightness or darkness of a color in relation to a neutral gray scale. The value symbol 0 is used for absolute black; the symbol 10 is used for absolute white.

veneer - Unconsolidated materials too thin to mask the minor surface irregularities of the underlying unit. A veneer will range between 10 centimetres and 1 metre in thickness and will possess no form typical of the materials genesis.

weathering - The physical and chemical disintegration, alteration and decomposition of rocks and minerals at or near the earth's surface by atmospheric agents.

APPENDIX F: Common and scientific names of plants referred to in this report.

Common Name	Scientific Name
Atriplex (saltsage)	Atripex nuttallii
Bedstraw, northern	Galium boreale
Bluegrass, Sandberg's	Poa secunda
Broomweed	Gutierrezia diversifolia
Buckbrush	See Snowberry
Buffaloberry, thorny	Shepherdia argentia
Cactus	See Prickly-pear
Cattail, common	Typha latifolia
Cinquefoil, shrubby	Potntilla fruticosa
Clubmoss, little	Selaginella densa
Cottonwood, western	Populus sargentii
Crocus, prairie	Anemone patens
Fescue, Idaho	Festuca idahoensis
Fescue, rough	Festuca scabrella
Fleabane, tufted	Erigeron caespitosus
Golden bean	Thermopsis rhombifolia
Grama grass, blue	Bouteloua gracilis
Greasewood	Sarcobatus vermiculatus
Hedysarum, American	Hedysarum alpina var. Americannum
Junegrass	Koeleria cristata
Kochia	Kochia scoparia
Lupine, silvery	Lupinus argenteus
Mallow, scarlet	Malvastrum coccineum
Needlegrass (spear grass or needle and thread)	Stipa comata
Needlegrass, green	Stipa viridula
Needlegrass, columbia	Stipa columbiana
Oatgrass, Hooker's	Helictrotrichon hookeri
Oatgrass, wild	Danthonia intermedia
Phlox, moss	Phlox hoodii
Porcupine grass, western	Stipa spartea var. curtiseta
Prickly-pear, plains	Opuntia polyacantha
Pussytoes	Antennaria sp.
Reedgrass, plains	Calamagrostis montanensis
Rose	Rosa sp.
Saskatoon	Amelanchier alnifolia
Sage, pasture	Artemisia frigida
Sagebrush, silver	Artemisia cana
Sedge, low	Carex eleocharis
Sedge, threadleaved	Carex filifolia
Silverberry	Elaeagnus commutata
Snowberry, western	Symphoricarpos occidentalis
Wheatgrass, northern	Agropyron dasystachyum
Wheatgrass, western	Agropyron smithii
Willow	Salix sp.

MAPS
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